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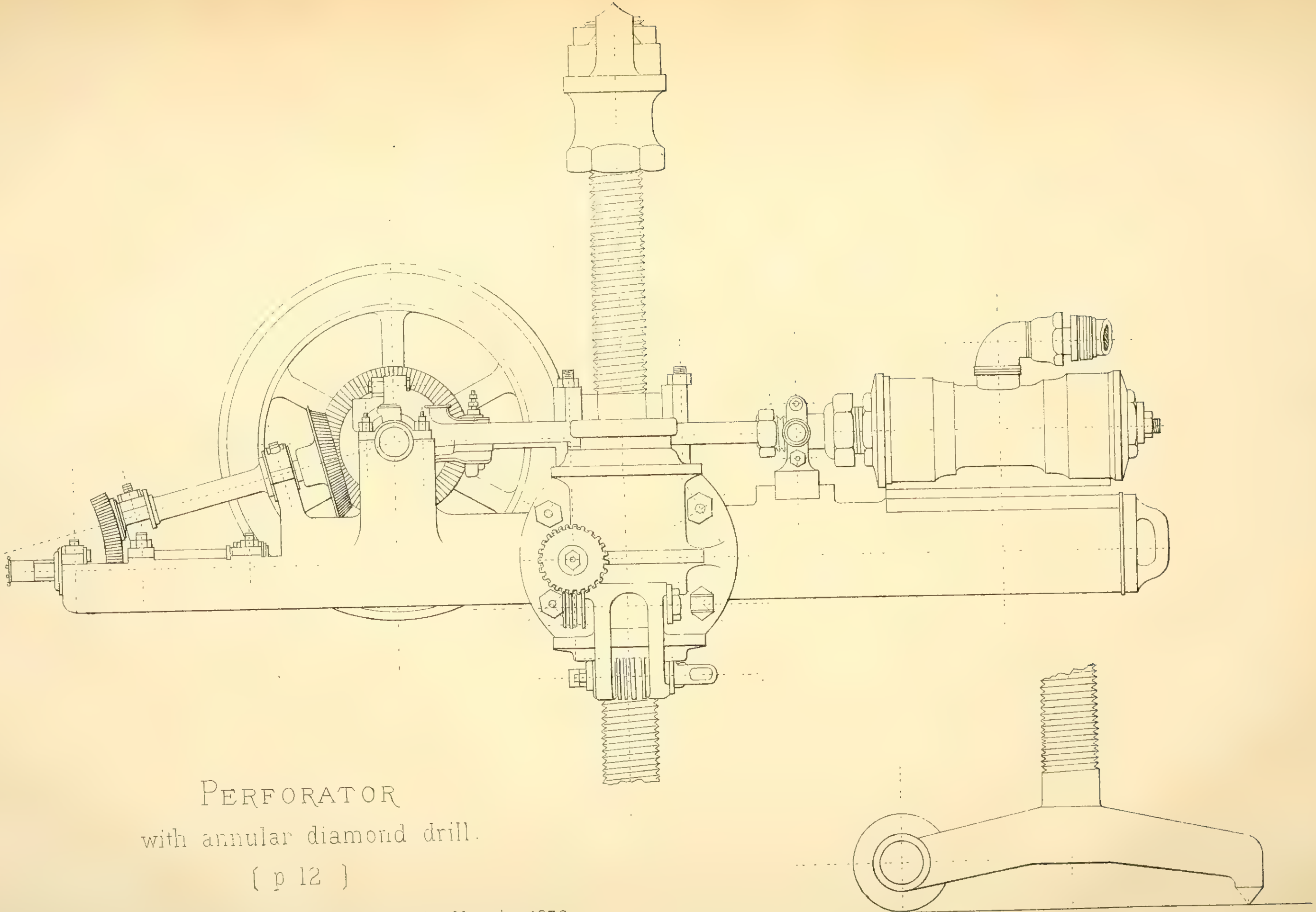

PERFORATOR
with annular diamond drill.
(p 12)

Engraved for Van Nostrand's Engineering Magazine, 1870.

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NO. XIX.—JULY, 1870.—VOL. III.

THE RAILWAYS OF THE FUTURE.

From "The London Times" of February 18th and March 1st.

Many persons in England are apt to suppose that we have come to the end of railway extension. The country is so well furnished with railways, and their financial results are so disappointing, that people are naturally loth to contemplate any further experiments on the established system. We are most grateful to the shareholders who have been so good as to supply us with these admirable roads, which have gone far to change the character of our civilization; but there are not many of us who care to follow their example, and we cannot be surprised if they should themselves be unwilling to continue the sacrifice of their fortunes for our benefit. Still, those who are acquainted with the demand for railways in foreign lands, in our colonies, and even in many parts of our own country, must be aware that we are speaking literally when we say that railways are as yet but in their infancy. There is an enormous demand for them in India, for instance; and yet every man of common sense must admit that, judging by all English examples, it is perfect madness to construct them on the received system, which means ruinous expenditure and dead loss. So thoroughly is the need of a great revolution in railway construction perceived, that some months ago we had to make the startling announcement that the Governor-General of India, dissatisfied with the slow progress and excessive cost of railways in his dominion, had actually sent to the United States for engineers who might confer with him as to the introduction of a more effectual and economical system—as if this were beyond the capacity of English engineers; and we propose now to give some account of further most important investigations tending to the same result as that so earnestly desired by Lord Mayo, whose conclusions, it may be mentioned in passing, coincided substantially with those formed independently by the Duke of Argyle at home.

It may be well to begin by reminding our readers that in October last (the 19th and 20th) we gave a pretty full account of what is known as the Fairlie system of railway working*—a system by which lines of the lightest construction and very narrow gauge may accomplish work hitherto deemed within the means only of lines of ponderous construction and broad gauge, and by which also the established lines of standard gauge may either partly diminish expenses, or, without additional cost, well nigh double their carrying capacity. The characteristics of the system will appear in the sequel; for the present we proceed to state that Mr. Power, the vice-chairman of the Poti and Tiflis Railway Company (a railway of 330 versts in the Caucasus), and Mr. Crawley,

* See pages 380, 540, 548, and 593, Vol ii. of this magazine.

the contractor for its construction, were so struck with the merits of the Fairlie system, that they strongly recommended its adoption to the Russian Government, not only for the line prepared in the Caucasus, but also for all lines throughout that vast empire, where railways are of prime necessity, and where now, according to the new plan, 5 miles can be provided at a cost which was swallowed up in 3 miles, according to the old one. The recommendation carried the greater weight, inasmuch as the works of the Poti and Tiflis Railway were far advanced, and on a length of 15 versts the rails are actually laid down. The proposition, therefore, was that the Russian Government would find their advantage, even on these conditions, of changing the plans on which so much work had been expended, taking up the rails which have been laid down, and constructing the line on a gauge of 2 ft. 6 in., or exactly half the standard Russian gauge. The Minister for Public Works, Count Bobrinskoy, seized upon the idea. Mr. Fairlie went to St. Petersburg to explain his scheme in detail; and the result of all is that an Imperial Commission has been sent over to this country to inspect the actual working of the system in various places, but chiefly on a wonderful little railway of 2-ft. gauge in Wales.

The chief of the Commission is Count Alexis Bobrinskoy, cousin to the Minister of Public Works. He is accompanied by a considerable staff of engineers, foremost among whom may be mentioned Professor Saloff, of the Russian Imperial Institute; and Mr. Roehrberg, the manager of the most successful railway in Russia; and by personal friends, as Count Camoyski and Count Alexander Berg, who take an interest in the question of railways. At the same time Mr. Fairlie offered to the Indian Government the opportunity of witnessing the experiments to be instituted for the Russian Commissioners; and they, being themselves anxious for the means of improving and economizing their own railway system, at once resolved to take advantage of the offer. They appointed a Commission, consisting of Lieutenant-General Sir William Baker, R.E., and a member of the Council of India; Mr. Thornton, Secretary of the Public Works Department in the India Office; and Mr. Danvers, Government Director of Indian Railway Companies, to accompany the party. Captain Tyler also, the Government Inspector of Railways, who has already reported favorably on the Festiniog Railway of 2-ft. gauge, attended on behalf of the Board of Trade, and Mr. Pihl, Chief Engineer of Railways in Norway, was present on the part of the Norwegian Government. Besides these gentlemen, who went to witness the trials officially, others took an interest in the various proceedings in a private capacity; chief among them being the Duke of Sutherland and Count Béla Széchenyi, son of the Hungarian patriot of that name, who was well known in England some 30 years ago. The Duke took an especial interest in the inquiry, as he is not only a director of the North Western Railway Company, but is himself the proprietor of a considerable length of railway on his Sutherlandshire estates.

The party thus constituted started off on Thursday morning last in a special train of saloon carriages, and halting at Crewe, to view the magnificent works of the North Western Railway—the largest in Europe, with the exception of those at Creuzot, in France—proceeded by Shrewsbury into Wales. At Welshpool they entered upon the Cambrian Railway system, and, with the advantage of brilliant weather, were conducted by Mr. Elias through the very picturesque country, up hill and down dale and round curves of hill-sides, by which the line passes to Portmadoc. At Portmadoc is the terminus of the line known as the Festiniog Railway, of 2-ft. gauge (really 1 ft. $11\frac{1}{2}$ in.), which was the principal subject of investigation.

The Festiniog Railway, which is pronounced by no less an authority than Captain Tyler, the Inspector of Railways, to be the most instructive line in the three kingdoms, and which seems destined by its success to give a new impulse to railway engineering, is itself one of the oldest in existence. The Act for it was obtained in 1832, but in the first instance it was constructed only for horse traction. It is a single line, $13\frac{1}{4}$ miles in length, with a branch of one mile connecting the slate quarries of Festiniog with the quays of Portmadoc. The terminus of Festiniog has 700 ft. of elevation above that at Portmadoc, the average gradient being 1 in 92, which is enough to secure the

descent of the trains on the return journey from Festiniog to Portmadoc by the impetus of gravitation, or, as the Welshman puts it, "by its own impittence." The line runs through a rude, rocky country, and has to adapt itself to an endless variety of curves along the contour of the hills, so that a train of any length has frequently to wriggle in serpentine fashion along 2 or 3 reverse curves, some of them sharp enough—the radius being $1\frac{3}{4}$ chains. On these curves the cant or super-elevation of the outer rails is never more than 3 in. The line, in the old days when it was worked by horses, was originally laid with rails of 16 lbs. to the yard. When, about 8 years ago, it was adapted to the locomotive, it was fitted with rails of 30 lbs. to the yard, most of which have been in use ever since. These, however, were found too light for the work, and are now being replaced by double-headed rails of $48\frac{1}{2}$ lbs. to the yard. The wheels of the carriages being less than 2 ft. apart, it is found convenient to arrange most of those for passengers after the fashion of an Irish car, with footboard overhanging the wheels. In this way the carriages are so low hung, and even carriages of the ordinary build are so near the ground in consequence of the small diameter of the wheels, that the expense of platforms at the stations is avoided. The whole expense of constructing and reconstructing the line, including tunnels, one of them 700 yds. in length, with branch lines to the slate company's inclined planes and the quays at Portmadoc—in all, 14 miles—has been £75,000, or at the rate of £5,378 a mile. The value of the rolling stock on the line is £28,000, or at the rate of £2,000 a mile. And now comes the most important point of all, which is that the original capital of the company is £36,185, and that all the extra money which has been laid out upon the line has been taken from revenue. In this sense, therefore, as the net revenue of the company is £10,622, it appears that the line yields a dividend of $29\frac{1}{2}$ per cent. on the original capital. A sum of £50,000, however, paid out of revenue for improvements and reconstructions, has been capitalized—making the total capital £86,185. In this sense the net revenue of the line yields a dividend of $12\frac{1}{2}$ per cent. Whichever way the fact is to be stated, it is a most remarkable one, and must fill many a shareholder's heart with envy.

The chief cause of this wonderful result is the narrowness of the gauge, which has enabled the Festiniog Company to economize in many ways. Thus, for example, the trucks for goods or minerals, even when fully loaded, have less of dead weight on a narrow than on a broad gauge. The best wagons on the standard gauge of 4 ft. $8\frac{1}{2}$ in. are reckoned to weigh 7 cwt., and to carry $12\frac{1}{2}$ cwt. of pig-iron or coal for every foot of their length, the dead weight being in the proportion of 56 to 100 of the *maximum* paying load, or 36 per cent. of the entire load. On the other hand, the wagon for a three-feet gauge is calculated to weigh $2\frac{1}{2}$ cwt., and to carry 8 cwt. for every foot of its length, the dead weight in this case being a very little over the proportion of 31 to 100 of the *maximum* paying load, and under 24 per cent. of the entire load. But there is still another view from which it can be shown that the wagons for goods and minerals on a line of a narrow gauge are not so disproportionate in weight to the weight carried as they are on the broad gauge. In goods traffic it is well known that the dead weight of a train is enormous—something like 70 or 80 per cent. of the total weight hauled. If goods are to be delivered on a long line of railway, they are in this country arranged in many more wagons than are necessary to hold them, because a goods wagon cannot, like a passenger carriage, unload itself, and the train cannot wait till the unloading at a particular station is finished. It has to pass on, leaving the wagon of goods for that station behind, and it is more than probable that for this purpose the wagon has been but half or a quarter loaded. This becomes serious when wagons that weigh several tons carry but a fraction, often a small fraction, of their own weight. Such a source of expense disappears to a large extent on a narrow-gauge line, where the wagons are comparatively small, and it is but one example of the saving which may be effected in the working of such a line, in addition to the saving of cost of construction in the first instance.

This remark would hold good of the narrow gauge in itself and worked according to the ordinary system; but it is in

the working of the Fairlie system that the greatest saving of all is effected, and it is mainly, indeed almost entirely, in consideration of the economy, the increased power, and the diminished wear and tear which this system implies, that a much narrower gauge than that now in general use has begun to find favor in the eyes of practical men. It was long before the Festiniog Railway Company could get an engineering firm to undertake to build a locomotive for a line of such steep gradients, combined with sharp curves, which they could guarantee. At last Messrs. George England & Co. undertook the task, and supplied engines which worked with perfect success, and then people began to believe in a railway of narrow gauge. One of Mr. Fairlie's engines has now been built for the line; it is called the Little Wonder, as the other engines which have preceded it have been called the Welsh Pony, the Little Giant, as well as by other diminutive names; and the result has so surpassed expectation in the power it exerts, in its gentleness of action, in its economy of fuel, in its saving of the rails, and in its adaptation to troublesome curves and gradients, that for the first time practical men have discovered that a gauge of 2 ft. 6 in., or of 3 ft. at the very utmost, is enough for the heaviest traffic. It is no secret that two engineers of eminence, Mr. Fowler and Mr. Fairlie, have pronounced a 3 ft. gauge to be ample for all the requirements of India, and there were men of position in the party which went down to Wales, men with characters to lose, who made what seems to us the hazardous statement that on a gauge of even 2 ft. 6 in. they would undertake, with the Fairlie engine, to work the heaviest traffic in the world—that of the London and North Western Railway. Be that as it may, it must be strange for those who can remember the battle of the gauges to find that what was then known as the narrow gauge is now in its turn attacked as being much too broad, and is even described in the terms which have been applied to more than one scheme of the Brunels as a gigantic folly. Our 4 ft. $8\frac{1}{2}$ in. gauge is now established in so many countries—it is used not only in Great Britain, but also in France, Belgium, Switzerland, Italy, Austria, Prussia, Denmark, Egypt, the Cape of Good Hope, Australia, the United States, and Central America—that we seem to think of it as a standard of perfection. In some countries there will be found a still broader gauge—as in England itself, in Ireland, in the United States, in Canada, in Australia, in India, in South America, in Portugal, in Spain, in Russia; but in very few will a narrower gauge be found. In England we have 14 miles on a 2 ft. gauge, and a few more on a slightly broader gauge; in Belgium there is a 3 ft. 8 in. gauge; in France, a 3 ft. 4 in. gauge; in India may be found a 4 ft. gauge; and in Norway and Sweden one of 3 ft. 6 in.; on the Mont Cenis Railway there is a 3 ft. $7\frac{1}{2}$ in gauge; and in Queensland one of 3 ft. 6 in.; and now we have opinion tending towards a gaugeof 2 ft. 6 in., or of 3 ft., as the standard for the future.

It is easy to determine on light railways of narrow gauge, and to construct them. The difficulty is to work them, and to work them in such a manner that their capacity and their economy shall bear comparison with railways of larger design and more elaborate construction. Hitherto railways of light construction and narrow gauge—that is, narrower than 4 ft. $8\frac{1}{2}$ in.—have been in little favor, because of the limited power and destructive effects of the locomotive. Take, for example, the oscillation. This is very destructive on the standard gauge; it is, indeed, the chief cause of destruction to the permanent way—a fearful item of expense. But it is still worse on a narrow gauge, and necessitates diminished speed on battered rails. Therefore, practically, a narrow gauge was but of limited application to ordinary traffic until a locomotive, such as that of Mr. Fairlie, could be invented free, or nearly free, from oscillation. And again, since a narrow gauge generally implies lightness of construction, and since lightness of construction implies sometimes roughness of workmanship, and nearly always such an adaptation of the railway to the surface of the country that it must dispense to a great extent with cuttings, viaducts, and other works, and must be ready to accept to the fullest extent possible a line of sharp curves and heavy gradients, it was necessary to devise a locomotive for it capable of good and safe speed on these conditions; and there was none such of sufficient note in existence until the double-bogie engine of Mr. Fairlie was produced,

which combined great size and power with freedom from oscillation, and with a short wheel base that could be worked round curves of 60 ft. radius and even less.

We cannot be wrong in saying that there was an absolute unanimity of opinion among all those who have witnessed the working of that narrow gauge railway at Festiniog, that the standard gauge of 4 ft. 8½ in. is far beyond all ordinary requirements. There may be some difference of opinion as to the precise gauge which is best. Mr. Spooner, the engineer of the Festiniog Railway, strongly advocated a gauge of 2 ft. 6 in., and he was supported in this view by practical men of great experience ; others seemed to hold that a gauge of 3 ft., giving greater freedom of space, would be best, but all appeared to be convinced that a gauge much narrower than that now in general use is capable of work which is at present little imagined in the railway world. If this view be correct, it involves some most important results. Thus, let us take an ordinary line costing £15,000 a mile, and compare it with one of narrow gauge worked on the new system, with power of carrying equal paying loads, and costing, as we have already indicated, three-fifths of the price of the other—namely, £9,000. With a traffic return of £20 every week for every mile, and deducting 50 per cent. for working expenses, the one railway would yield a dividend of about 3½ per cent., while the other would yield very nearly 6 per cent.; and this calculation makes no allowance for the more economical working of the narrow gauge, which is one of the main features of the system. If such a result be possible, it implies for public lines not a little encouragement to carry the railway system into every nook and corner of the kingdom where a moderate traffic may be obtained ; and for Government lines the reduction of tariff to the lowest point.

There seemed to be a unanimity of opinion also as to the success of Mr. Fairlie's engine adapted to the narrow gauge, and also on the broad gauge ; but it remains to be seen from the reports which will be furnished to the various governments, how far this unanimity extends. That the engine did some extraordinary work, is clear, as we shall presently show; but whether it is or is not to be recommended for adoption as a means of making the narrow gauge available to the utmost, is a point on which we have no information.

The object of the experiments on the Welsh railways was to ascertain whether or not the Fairlie engine increased the carrying capacity of a railway or diminished the cost of working it. With this view two engines were put on their trial —one, the Little Wonder, on the Festiniog Railway, of 2 ft. gauge, in North Wales; the other, the Progress, on the ordinary gauge of 4.8½, in South Wales.

The Fairlie engine consists of one long boiler, having two sets of tubes, with double fire-box between, and poised on two bogies. The arrangement is such that an enormously increased power is gained, with an extraordinary facility of movement upon swift curves, and with a freedom from oscillation which makes the Fairlie engine less destructive to the rails than locomotives of much less weight and power. The value of the system depends chiefly on the two bogies. It may be necessary to explain for some readers that a bogie is simply the name for a small truck. Instead of resting a wagon or a locomotive upon wheels of its own, which would make a long wheel-base that could not by any possibility get round very sharp curves, and that might get round moderate curves, but only with an amount of flange friction destructive to the rails and retarding speed, the wagon or locomotive is poised on two independent trucks, which have a short wheel-base, and which can, therefore, find little difficulty in curves of exceeding sharpness. In the small cabbage-garden at Hatcham, half-an-acre in extent, and laid out with rails of the ordinary gauge, Mr. Fairlie exhibits a steam carriage of 43 ft. in length, travelling at a speed of 25 miles an hour round curves of 50 ft. radius ; and they could with equal ease, and even greater safety, travel round curves of 25 ft. radius, which is only about that of an ordinary engine turn-table. The engine, therefore, on a pair of bogies, is prepared for a circuitous line of country, even on the standard gauge, which engines of the current type could not attempt.

The excellence of the bogie, however, does not merely consist in its adaptation to curves. It has an extraordinary effect in reducing oscillation. An ordinary

carriage rests directly upon the ends of axles, and when, through any defect in the road, there comes a disturbance in the plane of movement, the carriage, wagon, or locomotive rocks from side to side with immense violence, in a series of oscillations that hammer the rails to their destruction. It is calculated that these oscillations, in a train going at the rate of 30 miles an hour, add more than half as much again to the normal weight upon the wheel, and this is very serious in the wheels of a locomotive, each of which may be loaded up to 7 or 8 tons. The oscillation is reduced to a *minimum* by means of the bogie, inasmuch as the vast superincumbent weight of the locomotive is balanced on a pin, called the bogie-pin, in its centre. The bogie is a flat table upon wheels, with a great pivot in the middle of it. This table, and the wheels which support it, must naturally submit to whatever deflections there may be in the road, and so far it is impossible to get rid entirely of oscillation; but the great mass of weight above being poised in the centre of the bogie, and upon the centre of the roadway, is comparatively free from the influence of rocking, and transmits little or no hammering to the rails. A child can understand this by watching at see-saw the difference between placing a weight in the middle of the plank and dividing it between the ends. Now, it is an enormous advantage thus to steady the locomotive, to reduce the tendency to oscillate, and to get rid of the violent impact upon the rails. To steady the locomotive is to make its motion safer, and to diminish the chances of its leaving the rails—a point of considerable importance on the narrow gauge. The most important point of all, however, is to save the rails, which are so perishable under the demands of a heavy traffic, that there are instances in which the strongest steel rails have to be replaced in six months. The rails, where the line has any curve, are torn up by the flange friction of monster engines, with an immense wheel-base, and, whether the line is curved or straight, are hammered out by the oscillations of the same engines. We have already explained how, in the Fairlie engine, the flange friction is reduced by the substitution of bogies, with a short wheel-base, for the old plan, which necessitates a long one, and there is an absolute unanimity of opinion as to the disappearance of oscillation with the use of the double bogie.

We have only one word more of preface before we proceed to state what were the experiments with the Fairlie engine, both on the narrow and on the broad gauge. It is that the statements we are about to make do not rest solely on our authority. The various Commissioners and other observers met together, under the presidency of the Duke of Sutherland, compared their notes point by point, and came to a perfect agreement as to the facts which they were prepared to vouch for. Our facts, therefore, have the authority of documents signed by the Duke of Sutherland, as chairman of the different meetings which were held; by the Russian Imperial Government; by the Commissioners of our Indian Government; by Captain Tyler, of the Board of Trade, who acted as secretary, and was mainly instrumental in putting the facts into proper form; and by others who were well able to judge.

The Little Wonder is an 8-wheeled double-bogie engine* of four cylinders 8 3-16 in. in diameter, with a stroke of 13 in. The diameter of its wheels is 2 ft. 4 in.; its average steam pressure is 150 lbs.; its weight is $19\frac{1}{2}$ tons; its total length is 27 ft.; its total wheel-base is 19 ft., and the wheel-base of each bogie, which practically has alone to be considered, is 5 ft. This engine was first of all made to carry, from Portmadoc to Festiniog, a train made up of 90 slate-wagons, weighing $57\frac{1}{2}$ tons; 7 passenger carriages and vans, weighing $13\frac{1}{2}$ tons, and 57 passengers, weighing 4 tons—in all, 75 tons. Add to this its own weight, and we have a total load of $94\frac{1}{2}$ tons. The weight, it will be seen, was considerable, if we take into account the size of the engine, the narrowness of the gauge, the steepness of the gradients, and the sharpness and multitude of the curves. But the chief point of interest in this experiment had reference to the length of the train, which was 854 ft.—nearly the sixth part of a mile. A train of such a length on such a line had to run often upon two or three reverse curves, some of them with a radius as short as $1\frac{3}{4}$ chains, and it curled and doubled upon itself as it wound among

* See vol. 2, page 265.

the Welsh hills, so that the passengers in the front carriages could, sitting in their seats, make signals to the passengers in the hindmost ones. The engine, being in full gear, took this very long train up the hills, and in and out among the curves, at an average speed of 14½ miles an hour, and as a *maximum* speed of 26½ miles. Let us here add, by way of parenthesis, in order not to refer to it again, that some days afterwards a similar train, of 140 empty and seven loaded wagons, weighing in all 101 tons, and measuring in length 1,323 ft.—*that is, a quarter of a mile*—a train so long in fact, that there were parts of the road on which it had run on no less than five reverse curves—was by the same engine hauled up the hills at an average speed of 12½ miles, and a *maximum* of 16½. Now, what was the result observed in wriggling along these curves? It was generally observed (we now quote almost *verbatim* from the protocol signed by the chief witnesses) that even on curves of 1¾ chains radius, and at *maximum* speed, there was very little perceptible oscillation or movement on the engine or in the carriages, and by no means such as is felt on comparatively easy curves on ordinary railways. Nor must this remarkable point be forgotten—a fact almost incredible, but yet certified by competent witnesses—*that the oscillation diminished as the speed increased.* The speed, let it be added, is naturally less on a narrow gauge than on a broad one. Captain Tyler, the Government Inspector of Railways, was at first so doubtful of the safety of a high speed, on a railway of such narrow gauge, and such wild curves, as that at Festiniog, that he insisted on limiting the company to a *maximum* speed of 12 miles an hour. Since then, however, his doubts have been so completely dispersed, that he has removed all restriction as to the rate of speed; and as a matter of fact the Little Wonder, when necessary, works up to 30 and 35 miles an hour.

Next day the oscillation of the Little Wonder was put to a further test, and compared with that of the other engines—the Welsh Pony and the Mountaineer—which are of the ordinary type. In this series of experiments the speed was confined to 10 or 12 miles an hour on a comparatively level line, the gradient being only 1 in 1,200; and the line was laid with rails weighing only 30 lbs. to the yard, and not fished at the joints. On the Welsh Pony and the Mountaineer, tank engines of the ordinary type, weighing, the one 10 and the other 8 tons, it was found that there was a strong vertical oscillation and a lateral oscillation not so strong. On the Little Wonder, the double-bogie engine weighing 19½ tons, it was found that when riding on the foot-plates there was no oscillation whatever, vertical or lateral, perceptible—only "a smooth floating movement;" and that when riding on the bogie frames there was felt a slight lateral oscillation, though less than on the other engines. It is added that, the oscillation of the Fairlie engine being confined to the bogie, the influence of impact on the rails from the flanges of the wheels was far less than in the case of the Welsh Pony and the Mountaineer, the whole weight of these engines being in the course of their oscillations brought to bear upon the rails.

Next followed some rather tedious but very interesting trials as to the comparative powers of the two classes of engine. The Welsh Pony was selected to represent the common type of engine. It is a four-wheeled locomotive, weighing 10 tons, with cylinders 8⅛ in. diameter, having a stroke of 12 in., and with wheels 2 ft. in diameter. It was in the first instance tacked on to a load of 50 slate wagons full of slate, weighing 123½ tons. To this add 3½ tons for passengers and 10 tons for its own weight, and we get at the entire load of 137 tons. With this the Welsh Pony started from Portmadoc, and, running along the comparative level (1 in 1,200) of the Traeth Mawr Embankment, stopped on a gradient of 1 in 85, unable to proceed further, with 160 lbs. to the square inch of steam pressure. Hereupon half the number of wagons was removed, and the load (including passengers and the engine itself) was consequently reduced to 72 tons 17 cwt. With this load it was found that the Welsh Pony could mount the gradient of 1 in 85 easily enough. Being successful with 25 wagons, the question arose, could it manage more? It was then tried with 30 wagons, but on the gradient of 1 in 85 it was found that it could not start, though, since the engine-wheels did not revolve, there was no lack of adhesion. Then again the load was reduced to 26 wagons, weighing (with

passengers and engine) 73 tons 16 cwt., and it was found that this was the limit of the Welsh Pony's power. It started with such a load on the gradient of 1 in 85, and carried it as far as was necessary at the rate of 5 miles an hour—the average pressure being 150 lbs. to the square inch. If the Welsh Pony could carry nearly 74 tons up such a gradient, and with this load also start on it, what could the Fairlie engine, the Little Wonder, do? It was supposed that it ought to pull double. If the Welsh Pony could, on a gradient of 1 in 85 manage 26 wagons full of slate, weighing with all else 74 tons, surely the Little Wonder could manage 52. Mr. Fairlie said he was quite prepared for this; he would stake the credit of his little engine on its power to carry such a load; and to show that he could be generous, he even added three wagons to the load; he thought his engine could manage 55 wagons. However, as the Welsh Pony had first of all been tried with an excessive load, it was but fair that the Little Wonder should be similarly tried. A train was prepared of 72 loaded wagons of slate, weighing 138 tons 17 cwt., with empty ones weighing 43 tons 10 cwt.; and when you add to this 56 passengers, weighing 4 tons, and the weight of the engine itself, 19½ tons, you have a total load of 206 tons. With this load the Little Wonder started from Portmadoc (steam pressure, 165 lbs.), and passing along the level embankment, went up the gradient 1 in 85 with perfect ease, and to the astonishment of all the visitors, who crowded round Mr. Fairlie and shook him heartily by the hand on such a triumph. His engine was warranted to do double the work of ordinary engines, and on trial it was found equal to treble the work. But then arose the question: The Little Wonder has pulled such a load up the gradient of 1 in 85, having had a good start on the level embankment; can it start with this load on the gradient itself? It was, perhaps, scarcely fair to make the trial, inasmuch as the day was wearing late, and the engine-driver had, through a misapprehension, let the fire run low. Still the trial was made, and with perfect success. There is this further, however, to be added, that whereas the shorter trains were standing when they started, or attempted to start, partly on a curve of 4½ chains radius, partly on a straight line, the train of the Little Wonder being much longer (it was 648 feet), stood partly on the curve of 4½ chains radius and partly on a reverse curve of a little wider sweep, which, of course, means an increased resistance, and might be resolved into an increase of gradient. Also let us add here, to complete the statement, what really happened four or five days afterwards, that whereas these experiments last described were intended to test the extreme power of the engines, other experiments followed to show what the Little Wonder could do, not merely in a short run, but in its ordinary daily work between Portmadoc and Festiniog. It took, for example, a train 407 ft. long, and loaded to 141½ tons, from Portmadoc to Festiniog, at a *maximum* speed of 15 miles an hour and an average one of 11¼. The usual practical load, however, of the Little Wonder upon the average gradient of 1 in 92 is from 90 to 100 tons (exclusive of engine), at from 12 to 15 miles an hour. On a level it is calculated that its power is equal to the carriage of 450 tons, at a speed of 14 miles an hour.

After the experiments on the Festiniog Railway the exploring party met together in council, under the presidency of the Duke of Sutherland, to hear Mr. Spooner read a paper on the wonderful little line of which he is the engineer, and to compare with each other their notes and impressions. Mr. Spooner gave ample information on every detail connected with his railway, which in the year ending June, 1869, had a mineral traffic of 118,132 tons, a goods traffic of 18,600 tons, and a passenger traffic of 97,000 persons, but no night traffic and no Sunday trains. His paper will, no doubt, be published, and those who may be interested in the subject will find in it all the statistics of which we have given the cream. We only state here that he wound up his remarks by saying that he does not recommend for light railways a gauge so narrow as 2 ft. The gauge he recommends is one of 2 ft. 6 in. The large amount of traffic which can be done with ease on lines of this limit is, he said, really surprising, and with the Fairlie engine it is quite equal to that which can be earned on a 4 ft. 8½ in. gauge. Hereupon the discussion became general, but we can refer to only a few of the opinions which were expressed. The Duke of Sutherland said he wished

he had known more of the Festiniog Railway six years ago. "I have expended," said his Grace, "about £200,000 in promoting and making railways in the north. Had these lines been constructed on the narrow gauge, and had they in consequence cost only two-thirds of the sum that has been expended on them, I should have obtained a direct return on this large sum which I have laid out for the benefit of my estates and of the people in those remote districts. As it is, I shall suffer considerable loss." Then Mr. Crawley insisted in a vigorous argument on the perfect sufficiency of the 2 ft. 6 in. gauge, if worked on the Fairlie system, for the heaviest traffic, and on the folly, if this were sufficient, of adding another inch to the gauge. The argument may be sound as regards heaviness of traffic, but as other considerations besides the weight to be carried have to be taken into account, as, for example, the comfort of passengers and the bulk of goods, say in a cotton country, it is natural that there should be some difference of opinion as to the precise narrow gauge which is best. It will be seen that Mr. Fowler and Mr. Fairlie have both recommended a 3 ft. gauge for India; and it is not at all unlikely that this gauge may ultimately be adopted in Russia. It is important that on this subject we should give the views of Captain Tyler, whose scientific attainments, and whose large experience as the Government Inspector of Railways, give a peculiar value to his opinions. He stated in substance at the meeting of commissioners what will be found more elaborated in his printed reports. Thus, in a paper which he read on April 11, 1865, before the Institute of Civil Engineers, he says:

"It is illegal at present to construct any passenger lines in Great Britain on a narrower gauge that 4 ft. 8½ in., or in Ireland than 5 ft. 3. in. The Act 9 and 10 Victoria, cap. 87, provides (section 1), 'that after the passing of this Act it shall not be lawful (except as hereinafter excepted [with reference to broad gauge railways]) to construct any railway for the conveyance of passengers on any gauge other than 4 ft. 8½ in. in Great Britain and 5 ft. 3 in. in Ireland;' and (section 6), 'that if any railways used for the conveyance of passengers shall be constructed or altered contrary to the provisions of this Act, the company authorized to construct the railway, or, in the case of any demise or lease of such railway, the company for the time being having the control of the works of such railway, shall forfeit £10 for every mile of such railway which shall be so unlawfully constructed or altered, during every day that the same continue so unlawfully constructed or altered;' and section 7 gives power to the Commissioners of Woods, etc., or to the Board of Trade, to abate or remove such railways, so constructed or altered, contrary to the provisions of the Act. It would therefore appear to be necessary, before constructing any railways for passengers on a less gauge than 4ft. 8½ in., or before attempting to open for passenger traffic any railways so constructed subsequently to the year 1846 (in which the above Act was passed), to endeavor to obtain, if not its repeal, at least a modification of its provisions. That Act was passed after the report of the Gauge Commissioners, when there was a strong feeling against break of gauge, and when there was no immediate prospect of a third and narrower gauge being extensively required. But there is now an increasing demand for branch railways of a minor class. Many coal and mineral lines are in use on a narrower gauge than 4 ft. 8½ in., and others are about to be constructed with ultimate views of passenger traffic. It would therefore be an advantage if some smaller gauge were recognized; for, however objectionable the existence of different gauges on important through lines of communication may be, it is quite otherwise with respect to the use of a narrower gauge for feeding branches, in districts where a similar gauge to those main lines would not be commercially practicable. Passengers change carriages under any system at the junctions of less important branches, and it is considerably cheaper to transfer heavy goods from one railway truck to another, than to cart them for several miles, perhaps over different roads. The Festiniog Railway, on which the original gauge has necessarily been maintained, in consequence not only of its own works, but also of those of the tramways and quarry inclines running into it, is an extreme example, outdone only by the little engine which does the work of the shops at Crewe on a gauge of 18 in.; and the cost of that railway, under

the peculiar circumstances of its original construction and subsequent alterations, cannot be taken as a guide for the future. A gauge somewhat wider than 2 ft. would probably be desirable on any line to be now constructed, and it would hardly be worth while to desert the gauge of 4 ft. 8½ in. in Great Britain for any gauge wider than 2 ft. 6 in. But whatever the exact gauge, whether 2 ft. 6 in. or 3 ft., or any other dimension that might be considered most suitable for lines of *minimum* traffic, there can be no question that a system of branch lines, costing two-thirds of the branches now ordinarily constructed, and worked and maintained at three-fourths of the expense of those branches, would be of decided benefit to Great Britain and Ireland, and would be most valuable in India and in the colonies ; in fact, wherever there are people to travel, produce to be transported, or resources to be developed, where it would not be commercially profitable to incur the expense, in the first instance, of a first-class railway."

On the same occasion he observed :—

"It is important to ascertain what would be a suitable gauge in those instances where the traffic is not likely to be large. Farmers are now using portable railways for transporting the produce of their fields, for bringing in their harvests, spreading manure, etc., and there seems no reason why districts which could not support a railway on the gauge of 4 ft. 8½ in. should be altogether deprived of the advantages of railway communication. The question of gauge is, in one sense, a question of speed. Speaking roughly, on a railway of 2 ft. gauge, with 2 ft. driving wheels, travelling might be made as safe at 20 miles per hour as on the the Great Western, with its 7 ft. gauge and 7 ft. driving wheels, at 70 miles per hour. I have travelled on parts of this little line at the rate of 30 miles per hour with every feeling of safety."

And again, in a report on the Festiniog Railway, addressed to the Board of Trade, he says :

"The adoption of the locomotive power upon this little line is very important, and has evidently been a very successful experiment. The cheapness with which such a line can be constructed, the quantity of work that can be economically performed upon it, and the safety with which the trains run over it, render it an example which will, undoubtedly, be followed sooner or later in this country, in India, and in the colonies, where it is desirable to form cheap lines for small traffic, or as a commencement in developing the resources of a new country."

It should be noted particularly that the inquiries instituted by the Russian and Indian Governments had reference not merely to the narrow gauge, but chiefly to the narrow gauge as made available by the Fairlie engine. Having examined into the working of the Fairlie engine on the narrow gauge, they proceeded southwards to see the working of another engine of the same type on the ordinary gauge, on the heavy gradients of the Mid-Wales Railway and the Brecon and Merthyr line. The Progress was, we believe, the first built of Mr. Fairlie's engines, and has several imperfections, being, for instance, deficient in heating surface. But taking it as the first rough exemplar of the system, its performance is certainly remarkable. It is a double engine, with a four-wheeled bogie under each end, the cylinders 15 in. in diameter, the stroke 22 in., and the wheels (4 ft. 6 in. in diameter) are coupled together in both bogie frames, so that all the wheels of the engine are driving wheels. The extreme wheel-base is 22 ft., but, what has alone to be considered in practice, the wheel-base of each bogie is only 5 ft. The heating surface is on the fire-box 92 ft., and in the tubes 1,901 ft., making a total of 1,992 ft. The total weight of the engine when fully equipped is 54 tons, including 1¾ tons of coals and 2,000 gal. of water. Also, the engine is fitted with the Chatellier steam break, which Mr. Fairlie was the first to introduce into this country, and its extreme length, from buffer to buffer, is 32 ft.

On the 14th of February the Progress left the Three Cocks Junction on the Mid-Wales Railway with 39 loaded wagons, 3 break vans and about 50 passengers and workmen, making a total weight of 526 tons, including the engine. It measured 732 ft. in length. The day was bitterly cold ; the hour was late ; Mr. Fairlie was anxious to hurry on ; and not waiting for the engine driver, who knew the road, he mounted the engine himself, and set off with his load. The result proved that though he may be a first-rate engineer he is not a good engine-driver. A man may

be a very good judge of horses and yet not a good jockey. An engine requires as careful management as a horse; and Mr. Fairlie, driving his own engine, made it go through its heaviest work; but when he came towards the end of the journey, and there was a trifle more to be done, it turned out that there was not steam enough to go on. The amateur engine-driver, unacquainted with the gradients, had turned on the water supply at the wrong place, and soon found himself deficient in steam. The same experiment had, therefore, to be repeated next day under the guidance of the regular engine-driver, when it was perfectly successful. The engine had to carry the load of 526 tons up several gradients and on reverse curves; the gradients were 1 in 75, 1 in 162, and 1 in 90. The total distance run was 14 miles, from the Three Cocks to Builth, which was done in about an hour, including stoppages. On the same day the engine was taken to some still more severe gradients on the Brecon and Merthyr Railway. She left Tall-y-llyn with a load of 180 tons at 2.51 P.M. After running for 3 miles, for the most part on a descending gradient of 1 in 40, she was brought to a stand at Talybout station, where her tanks were filled. She started from Talybout at 3.13 P.M., with a steam pressure of 140 lbs., and ascended a gradient of 1 in 35 for half a mile. She then mounted a gradient of 1 in 38 for 6⅝ miles, and passed the summit of that gradient at 4.16, with 120 lbs. of pressure. She passed through the tunnel—660 long, a rising gradient of 1 in 68—in 2¼ min., and was stopped at the Torpantan station at 4.18 P.M., the pressure continuing the same. This portion of the line, as well as the rising gradient of 1 in 38, contained curves of 12, 16, and 20 chains radius, and the train was so long that sometimes it had to pass over reverse curves. These are facts formally authenticated by official witnesses; but further authentic reports have reached London stating that since these trials the Progress has done work still more characteristic of a Hercules. Her performance showed clearly that as the Little Wonder makes a narrow gauge railway of 2 ft. do work hitherto deemed within the means only of a much broader gauge, so the Fairlie engine, on the standard gauge, enormously increases its working capacity, and that, too, without additional cost in proportion. There is but one opinion of the engineers of the lines examined—Mr. Broughton and Mr. Henshaw—as to the effect of the Fairlie engine upon the rails. It does far more work than any ordinary engine, and yet it is far less destructive to the permanent way

The invention of the double bogie, by which this result is brought about, is exceedingly simple—so simple that one wonders it was not thought of before. It is like the egg of Columbus—when once it was poised anybody could do the same thing. Now, when we see by the double bogie how to poise an engine so that it shall not oscillate, so that it can be indefinitely increased in size, and so that it shall not murder the rails in its violence, one is inclined to say, "We knew all this before; there is nothing novel here." There is nothing novel, the principle is obvious; but it was never before so applied as to have a practical result, and Mr. Fairlie has the credit of introducing into the construction of the locomotive one of those slight changes which lead right on to a prodigious development and almost to a revolution. We are on the brink of a new era in railways—the narrow gauge era—an era of renewed activity, when every village, almost every farmstead, may have its railway; and if such an era be now at hand it is mainly because the Fairlie engine, by its increased power, by its adaptation to the sharpest curves, by its economy on the rails, and by its freedom from oscillation, even upon rude roads, has rendered it possible. Bogie has arisen to the incantations of Mr. Fairlie, and promises to make the old railways work better than ever they did before, and to make new railways, of lighter, smaller, cheaper construction, that will vie in performance with any of the old.

THE Khedive is raising funds, on his personal account, for the purchase of sugar-refining machines, the construction of railways through his private property, and the greater extension of sugar-cane culture.

THREE hundred and fifty-seven passengers were injured in one collision on June 23rd, 1869, at New-cross station.

BORING MACHINES FOR MINES.

(See Frontispiece.)

The report on mining and the mechanical preparation of ores, by Mr. Henry F. Q. D'Aligny, United States Commissioner to the Paris Exposition of 1867, contains an interesting chapter by M. Alfred Geyler, a French engineer, upon the machines for drilling or perforating rock, which were exhibited there, from which we have made the following extracts :

M. Geyler begins by stating that the application of machinery, worked by steam or other power, to the drilling or perforation of rocks originated in the United States, several machines having been in operation there previous to 1853. They were of two kinds, viz. : those which prepared the rock for removal by the use of powder, and those which cut the rock so that it could be broken away without blasting.

All these machines were worked by steam, and their mode of action was sometimes that of the common drill of the miner, sometimes that of a cutting tool, but in neither of these machines had the idea of boring like an auger into wood, or a drill into iron been applied.

For some years this last-mentioned mode of boring had been employed in France with better results than those of other machines which had preceded them.

Perforators, or rock-drilling machines, can be divided, according to their mode of working, into two principal systems—percussion and rotary.

They may be worked either by hand or by some motive power, such as steam, compressed air, or water.

I. MACHINES FOR BORING BY PERCUSSION.

Only one machine of this kind, intended to be worked by hand was exhibited. It is called Trouillet's Excavator (cavateur Trouillet), and is employed for enlarging round holes from the bottom upwards. They can then receive much larger charges of powder. It consists essentially of a tube or pipe, of the same diameter as the hole, in which a stem or iron bar slides freely and gives motion to two steel cutters, which are hinged upon the bar. Whenever the bar is pushed down one end of each of the cutters is thrown outward and describes an arc of 90 deg., and when the bar is pulled up again they re-enter the pipe. If the whole machine is turned slowly the hole will gradually be enlarged, and as the height of the tool above the bottom of hole can be changed a cavity of any (not more than 0.30 metres) diameter and length can be formed. Cutters of different sizes are used successively, when a large cavity (0.30 inches in diameter) is to be formed.

BORING BY STEAM OR COMPRESSED AIR.

The boring machines of the second class, actuated by steam or compressed air, are divided into two systems, according to their mode of working.

The first includes the apparatus which serve to make the holes to be blasted with powder. The second comprises the machines intended to cut out the rock the size of the gallery by direct action, unaided by powder.

The best known power machines for boring blasting holes are—

1. Those of M. Sommeilier, employed at Mont Cenis.
2. The apparatus of Mr. Döring, of Prussia, employed for the last three years at the Vieille Montagne mine.
3. The borer of Mr. Bergstroem, of Sweden.
4. And lastly, the steam-borer of Mr. Herman Haupt, C. E., of Philadelphia, United States.

The first three are worked by compressed air, and consist essentially of three parts: a cylinder, by which the compressed air communicates a reciprocating motion to the drill, a mechanism by which the drill is turned, and a mechanism by which the working parts are made to advance as the hole becomes deeper. In the first two machines the latter mechanism is automatic ; in the third it is moved by the workman. In Mr. Haupt's machine steam is substituted for compressed air, and he has so arranged the apparatus that the drill always strikes the rock with the same force, and that the advance of the tool varies with the hardness of the rock. All the above apparatus act by percussion, and are, therefore, very liable to be broken and put out of order. The following account of the working of M. Sommeilier's

machine will give an idea of the amount of repairs which these machines require :

The apparatus placed before the breast of the gallery to be attacked carries 8 drills, which cover a section 4 metres wide by 3 metres high, equal to an area of 12 square metres. Eighty holes are bored, 6 of $6^m.09$ and 74 of $0^m.04$ diameter, and $0^m.90$ deep. The daily work has varied evidently according to the hardness of the rock ; in March, 1863, it was $1^m.10$ in 24 hours, in April $1^m.40$, and in some parts of the strata even $2^m.50$; but when the bank of quartz was met (which was 308 metres thick), the advance was hardly $0^m.50$ per day.

During the month of March, 1863, it was shown that each explosion of $0^m.70$ to $0^m.80$ required 6 hours for boring the holes, and 4 hours for the miners carrying away the rubbish.

The staff employed for the boring of the holes during 24 hours was as follows :

	Men.
Two shifts	16
Miners	2
Laborers for taking away the debris	8
Superintendents	2
Total	28
Although we have not to take into account the motive engines, we ought to add that the compressors required	9
Total	37

If we examine the staff employed in repairing the tools, we remark that in 1863, for 8 machines working, there were 60 in the shop. At this time, when the work is carried on both from the French and the Italian sides, the number of engines working is 16, and of those in the workshops repairing 200.

In 1863, as we have stated, for repairing 8 perforators working in a coarse sandstone (*grès à gros grains*), the staff attached to the workshops was composed of—

	Men.
Blacksmiths repairing tools and parts of Machines	14
Fitters, turners, firemen, and boiler-makers,	10
Total	24

Thus 24 men were occupied daily in repairing 8 machines. At this time the number is much larger ; unfortunately it is almost impossible to obtain exact accounts of the cost of repairing. All that we know to be exact is that at this time the work has been offered to a company at 6,000 francs per running metre, giving them all the apparatus ; they to repair the tools and clear away the dirt. This was refused, although the price was equal to 500 francs per cubic metre.

The enormous shocks which the machine was subjected to obliged them to change the iron beds for Krupp steel ones ; the springs often broke, and the drills cannot advance $0^m.20$ or $0^m.30$ without requiring repairs.

Even admitting the possibility of constructing these machines strong enough to resist these causes of destruction, we still say the percussion system presents such disadvantages that render its adoption impossible ; for when, by the blows of the drill, pieces of rock are broken off, and instead of being thrown out they are still subjected to the blows and reduced to powder, this causes a loss of work. It is true that, to aid in clearing the holes at Mount Cenis, they injected water under a pressure of 5 atmospheres, but this was abandoned because the tool became clogged. At this time a jet of air at 5 atmospheres is forced in and drives the dust from the bottom of the hole. This dusty atmosphere must be injurious to the health of the workmen.

Besides, when the drill has penetrated the rock a short distance, it is no longer guided and supported, and its vibrations are so considerable that they can only be compared to those of the axles of railway wheels. These vibrations evidently prevent the making of a uniformly circular hole, and leave ridges in the hole, which prevents the use of cartridges, which are much better than to ram in powder.

We ought, lastly, to add that the boring of the holes is but a part of the work to be done ; there still remains the work of of clearing out and removing the dirt and debris. It is necessary that the boring machine should be solid enough to require little repair, so that the cost for tools shall not be altogether out of proportion to the work done.

An account of some of the above machines will be found in "Spon's Dictionary of Engineering," in the article, "Boring and Blasting."

BEAUMONT'S AND LOCOCK'S DRILLING ENGINE.

This machine is worked by compressed air ; its object is to pierce a gallery 2

metres in diameter entirely by the machine, aided by powder, for disengaging the core of rock, which is left inside of the annular trench cut by the drills. This machine is composed of a circular cast-iron plate, which carries on its circumference 50 drills, and at its centre a single drill. The diameter of the plate is the same as that of the gallery to be driven. It is fixed on a hollow iron shaft about $\frac{2}{3}$ of its length, being a piston moving in a cylinder, by means of which a reciprocating motion is given to the drills, while at the same time the disc is turned. We will not dwell upon the description of the machine, which has seen the day light, but which we think will never see the end of a gallery in a mine or tunnel. It weighs more than 10 tons.

II. BORING BY ROTATION.

We have before pointed out the imperfections inherent and inevitable in the system of boring by percussion, and however ingenious the combination given to the apparatus, we are convinced they are destined to disappear and to give way to the system of rotating borers, which will now be described.

The borers by rotation are divided, like those by percussion, into two classes ; the first comprises those worked by hand, the second those which require water, steam, or compressed air as the motive power.

Among the first we remark the borer of Lisbet and Jacquet, Mr. Leschot's borer, constructed by Mr. Pitet, and lastly Mr. Trouillet's rotating excavator.

BORER OF LISBET AND JACQUET.

The tool of this borer is formed of a blade of corrugated steel $0^{m}.007$ thick and $0^{m}.035$ wide, twisted like an auger bit, so that it draws from the hole the debris of the rock detached by the cutting end, which has two edges, making a very obtuse angle, like a drill for perforating metals. This tool offers a certain peculiarity ; the drill, instead of advancing according to the hardness of the rock, works in the manner of a screw turning in a fixed nut, and is expected to penetrate at a certain rate, irrespective of the hardness of the material being bored. By this arrangement, if the rock is too hard to be overcome by the motive power used, the drill either stops or breaks. The screw of the drill-carrier has 4 threads per centimetre, so that the rate of progression is $0^{m}.01$ for 4 turns.

The frame of the drill-carrier is ingeniously arranged, to enable it to be moved rapidly and to make holes in all directions.

The support or frame for this drill consists of an upright, or standard, to be sustained in the drift, or gallery, by steel points at each end, one of which can be forced against the roof by a screw, while the other rests upon the floor. The body of this standard is double, and so made that a sliding-drill support can be raised or lowered in it, and be sustained at any desired height by means of pins. Motion is given to the drill by means of a winch and ratchet working in the usual way.

From experiments made with this machine it was found—

1. That the erection and working of the apparatus require considerable skill and judgment.

2. That in granular and homogeneous stone the borer acts well.

3. That in hard sandstone and quartz it has no action on the rock, and the tool wears up quickly ; also that it works irregularly in rocks that contain masses of quartz.

4. And lastly, that in wet rocks the work is difficult, and the rate scarcely appreciable.

LESCHOT'S DRILL.

The imperfections that Mr. Leschot, civil engineer and pupil of the Central School, had recognized in the use of iron or steel in the boring of hard rocks or of metals, the drills softening rapidly, and often producing only an advance of $0^{m}.07$ to $0^{m}.10$ per hour, gave him the happy idea of applying a rotating tool acting in the manner of an annular cutter, and in which steel teeth should be replaced by diamonds. To accomplish this, he sets into a tubular washer or ring, about $0^{m}.005$ or $0^{m}.006$ thick, black diamonds projecting $0^{m}.0005$ at the most, some from within, some from without, and some in front.

The opposite end carries an adjustment like a bayonet joint, which admits of this crown being adjusted upon a tube as a bayonet is placed upon a gun-barrel. He imparts to this ring so arranged a rotary movement, and at the same time presses

it with considerable force against the stone to be bored.

The first experiments that were made with this apparatus, which was mounted on a frame something like that of the Lisbet borer, led to the belief that this new system of boring the rock would be a complete success. In a granite of medium hardness, two men could bore $0^m.025$ per hour; the cylindrical core left in the centre was $0^m.031$ in diameter, and the annular groove $0^m.043$ in diameter; consequently the part pulverized was equal to a cylinder $0^m.012$ thick.

Unfortunately experience has not confirmed the happy debut of this apparatus; not because the employment of the ring was bad, but solely on account of the mode of advancing the drill, which depends on the velocity of the rotation of the cutting ring. The principle of this arrangement for advancement is evidently defective, for it is impossible to have a constant regular rate of advance in rocks which, by their nature, are constantly varying in hardness. In the soft parts of the rock, the advance of the tool not having been quick enough, it did not produce its maximum amount of work; while in the hard rocks, quartz for instance, the advance was too rapid, and the diamonds were either displaced or reduced to powder.

TROUILLET'S ROTATING EXCAVATOR.

This, like the percussion apparatus by the same inventor, is intended to enlarge the lower portions of ordinary drill holes so as to make chambers for the reception of powder. It is similarly constructed, except that the work is performed by the rotation of steel cutters, attached to a central stem or shaft, to which motion is given by two cranks and gearing. The weight of the apparatus is 60 kilogrammes, and its price is 450 francs.

DE LA ROCHE-TOLLAY AND PERRET'S BORING APPARATUS.

The complete apparatus of Messrs. De La Roche-Tollay and Perret is composed of four distinct parts:

1. The carriage which bears the borer.
2. The motive power.
3. The borer.
4. The tool.

Carriage or Support.—This borer is intended to be arranged differently, according to the conditions under which it is to work. When it is intended to bore but one hole, a single tool is used; when the front of a gallery or a tunnel is to be pierced in several points simultaneously, several boring machines will be indispensable. Consequently, in each particular case, the carriage or tool-bearer should be modified according to the local requirements. We do not, therefore, enter into the relative details of this part of the machine; we will merely state that Messrs. Huet and Geyler, engineers, have studied the different arrangements of the tool-carrier, and they have succeeded in rendering the working of the borer or borers easy and quick, in permitting them to assume any required direction on the carriage which bears them, and in giving an arrangement by which the carriage or support can be attached easily to the roof or wall of the gallery as well as upon the sides, and removed away rapidly to allow the powder to be fired and to carry away the debris. This arrangement is shown in the frontispiece.

Motive power.—This hydraulic motor has been contrived by Mr. Perret, civil engineer at Bordeaux; it is composed of a horizontal cylinder bolted on the frame of the borer.

This cylinder carries at its upper part a nozzle, to which is adapted a pipe in india-rubber, intended to conduct the water to the engine.

In this cylinder a bronze tube is fitted, which we call the regulator. This is bored and turned with the greatest nicety, and is pierced with port-holes at the end. It receives a reciprocating motion from an eccentric, made of one piece, upon the axle of the engine.

Two boxes furnished with segments in bronze, pressed by steel springs, maintain the regulator rigorously in the axis of the inner cylinder, which serves to envelop it. These segments have the effect of stopping the passage of the water round the regulator during its longitudinal movement.

In the interior of the regulator there is a movable piston $0^m.055$ in diameter, furnished with capped leathers, upon the two faces of which the water alternately exerts its pressure. The length of stroke is $0^m.120$. A connecting rod changes it into a continuous rotary motion in connection with a cranked shaft provided with two fly-wheels acting as regulators.

In order to ascertain the power of this new motive engine, we took 300 litres of water, the pressure of which varied from 3 to $9\frac{1}{2}$ atmospheres, and we proved by means of Prony's break, in seven experiments that we made, that the practical result of the engine was 47 to 57 per cent. of the theoretical effect. This machine represented under the maximum pressure of $9\frac{1}{2}$ atmospheres, theoretically 3.82 horse-power, and practically 2.11 horse-power.

We shall presently show that the regular speed of this little machine ought to be from 200 to 250 revolutions per minute. This is represented by 140 litres of water per minute, and a practical effect of 1.70 horse-power, the water being at a pressure of 8 atmospheres.

It will at once be seen what an important service this motive power will render when there is a sufficient supply of water. For example, at Mont Cenis (Bardonnèche) the torrent of Melzet has a fall of 45 metres; admitting that it is 35 metres only, to give allowance for loss, it follows that each machine on Mr. Perret's principle would expend 320 litres per minute for one boring tool; thus, for the eight machines which are at work on the face of the rock, 2,560 litres, or 44 litres per second, would be required. The quantity of water at present used for working the compressors is 600 litres. It will be claimed as an advantage that the compressed air serves to aerate the gallery; this is true, but we find in the official returns that it requires for working the 8 borers 6,250 cubic metres of air for 24 hours, while 2,160 cubic metres is sufficient to renew the air vitiated by the 15 men at work in the head of the gallery; it is also true, that they have sought to establish the fact that the balance, 4,000 cubic metres, was necessary to expel the noxious gases produced by the explosion of the powder; but practice has proved that much more powerful and artificial means were required for this purpose. It would appear to us more rational to employ a part of the 566 litres remaining to work a Perret machine to drive an air ventilator. We ought also to add that the erection of the compressors and their buildings at Bardonnèche has cost 1,250,000 francs, and three-fourths of this expense would have been saved by the employment of Mr. Perret's machine.

The boring machine of Mr. Perret is composed of a six-sided cast steel shaft, $1^{m}.45$ long, bored throughout its entire length with a hole $0^{m}.016$ diameter. This axle receives the boring tools at one of its extremities.

The other extremity of the axle carries a bronze piston $0^{m}.12$ diameter, upon which the requisite pressure is exerted for maintaining and pressing the drill against the face of the rock. This pressure is varied according to the hardness or the nature of the rock. A pressure of eight atmospheres is abundantly sufficient for boring hard rocks, such as the quartz of Mont Cenis and the granite of the Pyrenees. The pressure should be diminished for calcareous rocks to five or six atmospheres at most. Thus, with a pressure of eight atmospheres, the effort on the drill is equal to 784 kilogrammes.

The water employed to act against the piston of the propeller is conveyed by an india-rubber hose, the extremity of which is provided with a cock to regulate the pressure as may be required.

To remove the perforating tube after a hole has been cut, the passage of the water to the cylinder is intercepted by a cock, and the flow is directed against the front face of the piston, admitting, at the same time, of the cylinder being emptied. In this manner the tube can be replaced with the greatest facility.

The perforating shaft is fitted on the inside with a bronze frame, accurately bored to a depth of $1^{m}.14$, for the propelling piston to work in. Holes from $0^{m}.90$ to $1^{m}.00$ deep, and from $0^{m}.035$ to $0^{m}.06$, can be bored by this machine.

The tool-bearing shaft traverses an iron socket held between two bearings arranged in front of the framing. The socket is provided with a bevel pinion, to which motion is imparted through the medium of an inclined shaft by a brass wheel keyed on the main shaft.

From the foregoing it will be seen that in order to apply this borer to the Mont Cenis works, it should have a piston $0^{m}.16$ diameter, since the pressure of the water there is only $3\frac{1}{2}$ atmospheres.

The perforating tool made use of until recently by Messrs. De La Roche-Tollay and Perret is the Leschot ring previously described, but there are still some points to be explained to complete the information relating to this kind of drill.

It is understood that after the ring has been attached to the six-sided perforating shaft, if it is rotated at a speed of about 200 revolutions per minute, by the effect of pressure exerted on the propeller piston, the black diamonds brought in contact with a softer substance will cut and wear it to an extent which will depend on the pressure on the piston and the hardness of the rock. By continuing this labor the groove can be made to a great depth, and the cylindrical core which remains attached to the rock enters the hole through the axis of the tool-carrier. When the operation is terminated the core is taken out in the shape of quite a regular cylinder, which only breaks when the rock is of a brittle nature, or has been previously cracked. It is evident that the use of this cutting ring saves considerable power, since a part of the rock is not pulverized. In the example which we have given in describing the Leschot perforator, the effort was only 61.441 tons per hour, while it would have been 204.5 tons if the entire matter had been pulverized. The ring employed by Messrs. De La Roche-Tollay and Perret is only $0^{m}.035$ outside diameter, and the core worked was $0^{m}.014$ in diameter.

Cost of the tools.—We will now reply to an objection which has been raised as to the price of the tool. It is true that when the ring was first used a difficulty existed in the selection of the diamonds, which, from the nature of their cleavage, would be the most serviceable. The setting was not always performed as solidly as could be desired ; but these difficulties have disappeared. We have examined two rings which were worked for seven months at the Exposition, and which have perfectly resisted. We believe that we can affirm that in a hard stone like granite, a ring properly worked will cut holes to an aggregate depth of 150 metres. A ring for boring holes, $0^{m}.036$ diameter, costs about 150 francs, but as the black and opaque diamonds used in its construction are ordinarily employed in the shape of dust for polishing transparent diamonds, and as their wear during the act of perforation is very slight, they can be extracted from the socket in which they are set, and be returned to the trade with a depreciation proportionate only to the diminution of weight. The diamonds extracted from a worn-out ring generally fetch from 70 to 80 francs—that is to say, about one-half of their first cost.

The following are the results of the experiments made during the Exposition. The pressure on the propelling piston was eight atmospheres, and the speed varied from 250 to 280 revolutions per minute.

Advance per minute: In the pure Mont Cenis quartz, $0^{m}.054$; in the Morvan porphyries, $0^{m}.042$; in granite, $0^{m}.050$; in ———, $0^{m}.018$; in very hard calcareous dolomite, $0^{m}.080$.

The holes were perfectly regular, and, being so, were well adapted to the use of powder cartridges, which are much less dangerous than the ordinary use of powder.

As the pressure of the water injected into the hole through the hollow is the same as that acting on the piston, the powdered debris are washed away with the greatest facility.

The hydraulic engine and the perforator have worked every day, during four hours, in a period of seven months, without necessitating any serious repairs. The most important were, repairing the piston-head bearings of the water engine and verifying the state of the segments belonging to the engine.

The weight of the entire apparatus is equal to that of those used at Mont Cenis, viz., about 200 kilos. ; its price, including the engine, but without the support, is 2,500 francs.

We cannot refrain from making a comparison between this perforator and the one employed at Mont Cenis. Its solidity, proved by 7 months' work, gives the assurance that 20 to 22 of these perforators would be sufficient for the heads of both galleries, including duplicates, instead of at least 220 actually existing. Mr. Sommeilier's perforators cost the same as those of Messrs. De La Roche-Tollay and Perret. The staff would be 4 times less, for one man can easily attend 4 perforators ; thus 4 men instead of 16 would suffice for 24 hours at the two galleries.

The repairs to the rings require neither forges, lathes, nor workshops; and we are convinced that a workman to each gallery would be sufficient for the repairs of all the perforators. We have stated that the rate of advance in the Mont Cenis quartz was $0^{m}.054$ per minute, under a pressure of 874 kilos. on the propelling piston ;

therefore a hole $0^m.90$ could have been driven in 16 minutes, say 20, and as each perforator should make 10 holes, say $3\frac{1}{2}$ hours, even doubling this time for preparing the work, it will be seen that 5 stopes can be done in 2 days, including the time for blasting and clearing away the debris, which is equivalent to an advance of $2^m.25$ per diem, instead of barely $0^m.50$, the actual rate of advance.

The apparatus of Messrs. De La Roche-Tollay and Perret is not subjected to any shock ; the pressure is exerted on the rock irrespective of the speed of the tool, and such pressure can be regulated as may be desired ; and when water power is obtainable, which is generally the case in mines and tunnels, the motive power actually costs nothing.

Mr. Perret's machine can also be worked by compressed air, and for this it would be sufficient to add a hydraulic accumulator to the perforator carriage. Such an accumulator would be but small, since the volume of water required for advancing the piston 1 metre is $9\frac{1}{2}$ litres, it would be sufficient to add 2 or 3 litres per hole, 1 metre deep, for washing out the holes.

ON SOME MECHANICAL EFFECTS OF MAGNETIZATION.

From "The Engineer."

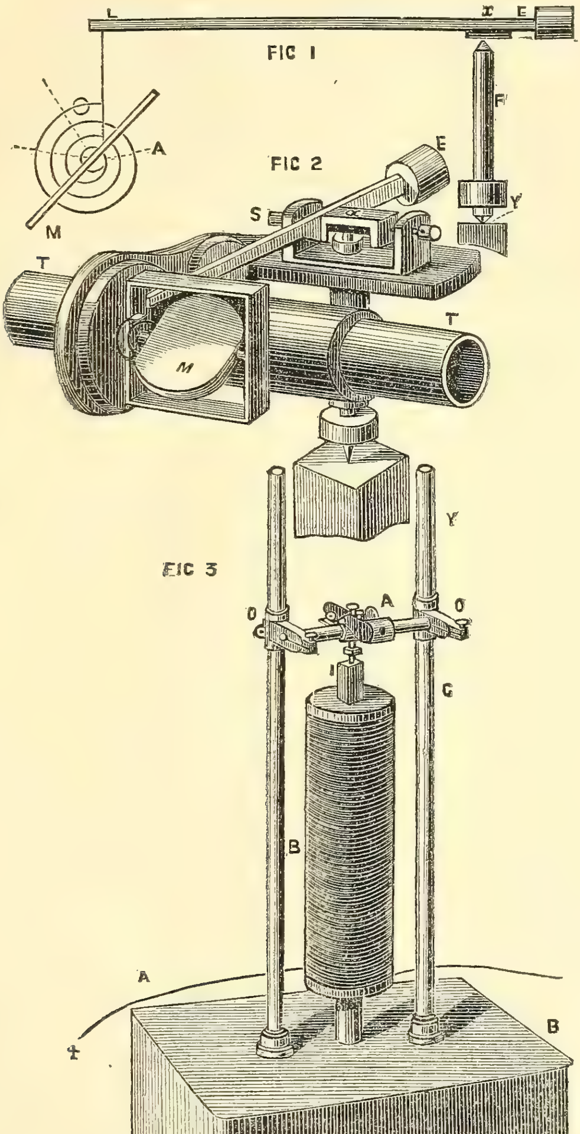
We are indebted to the courtesy of Prof. Tyndall for the following account of a piece of apparatus used by him in his researches in magnetism, which cannot but interest our readers. We are thus able to anticipate by a short period the publication of his new work, in which, among other essays, letters, and reviews, this apparatus and its use will be explained :—

"Wishing in 1855 to make the comparison of magnetic and diamagnetic phenomena as thorough as possible, I sought to determine whether the act of magnetization produces any change of dimensions in the case of bismuth, as it is known to do in the case of iron. The action, if any, was sure to be infinitesimal, and I therefore cast about for a means of magnifying it. The idea which appeared most promising was to augment in the first instance by a lever the small amount of change expected, and to employ the augmented effect to turn the axis of a rotating mirror. By making the axis small enough it was plain that an infinitesimal amount of rectilinear motion might be caused to produce a considerable amount of angular motion. This I proposed to observe by a telescope and scale after the method of Gauss. I consulted Mr. Becker, and thanks to his great intelligence and refined mechanical skill, I became the possessor of the apparatus now to be described.

"A B (Fig. 3) is the upper surface of a massive block of Portland stone. It is 21 in. wide, 13 in. deep, and 29 in. high. In it are firmly fixed two cylindrical brass pillars C, C, 1 in. in diameter and 35 in. in height. Over the pillars pass the two clamps O, O, and from the one to the other passes a cylindrical cross bar, 11 in. long and $\frac{3}{4}$ in. wide. This cross bar is capable of two motions—the first up and down the two pillars C, C, parallel to itself ; the second being a motion round its own axis. To this cross piece is attached the magnifying apparatus A.

"The bar to be examined is set upright between the two pillars, being fixed firmly to a leaded screw embedded in the Portland stone. It is surrounded by an electro-magnetic helix B. On the top of the bar I rests one end of a small cylindrical brass rod, with pointed steel ends. This rod fits accurately into a brass collar, moving up and down in it with the least possible friction. The other point of the rod presses against a plate of agate very close to a pivot round which the plate can turn. The agate plate is attached to a brass lever 2.1 in. long, whose fulcrum is the pivot just mentioned. Any motion of the point against which the rod presses is magnified about 50 times at the end of the lever. From this end passes a piece of fine steel fibre round the axis of a rotating mirror, which turns as the end of the lever moves. The mirror rotates with its axis. For accurate experiments an illuminated vertical scale is placed at a distance of about 12 ft. from the mirror, which is observed through a telescope placed beside the scale. A naked section of the magnifying apparatus is given in Fig. 1. The magnifying apparatus

is shown in detail in Fig. 2, where M is the mirror; S and S′ are two centre-screws, whose points constitute the pivot round which the lever turns; E is a small counterweight; T, T is the cross-piece to which the magnifying apparatus is attached; I is the bar to be magnetized, F the brass rod with the pointed steel ends, divested of its collar, and pressing against the plate of agate near the pivot *x*.



From the end L of the lever the steel fibre passes round the axis *a* of the mirror M. When the bar I changes its length, the motion at L turns the mirror; and when I resumes its primitive length the mirror is brought back to its first position by the spiral hair-spring shown in the figure.

"In a lecture, of which the following is an abstract, the instrument just described was employed to show the elongation of a bar of iron by magnetism. It is the

instrument referred to in 'Heat as a Mode of Motion,' 3rd edition, p. 85. Merely breathing against an iron bar produces a visible expansion. By squirting warm water from a syringe-bottle against the bar, and by employing ether or alcohol in the same way for cooling, the luminous beam which forms the index may, in a few seconds, be caused to pass through a distance of 20 or 30 ft.

"ON A MAGNETIC EXPERIMENT.*

"Some years ago I devised an apparatus to enable me to investigate certain mechanical effects which accompany the act of magnetization. I wished to apply this apparatus to diamagnetic bodies as well as paramagnetic ones—to bodies such as bismuth, as well as to bodies such as iron. I intend this evening to show you the action of this instrument, and to lay before you some explanation of experiments of which mine are merely confirmatory.

"Let us pass quickly in review the excitation of this wonderful power of magnetism. Over the poles of this strong horse-shoe Logeman magnet I pass a bent bar of steel, whose arms are the same distance apart as those of the magnet. The steel bar suddenly obtains the power of attracting this iron keeper, and holding it fast. On reversing the stroke of the steel bar its virtue disappears; it is no longer competent to attract the keeper. I continue the stroke of the steel bar in the last direction, and now it is again competent to attract the iron; thus at will we can magnetize and demagnetize this bent piece of steel.

"At the other side of the table you observe another mass of metal, bent like the Logeman magnet, but not like it, naked. This mass, moreover, is not steel, but iron, and it is surrounded by coils of copper wire. At the present moment this huge bent bar is so inert as to be incapable of carrying a single grain of iron. I now send an electric current through the coils that surround it, and its power far transcends that of the steel magnet on the other side. It can carry fifty times the weight. It holds a 56 lbs. weight attached to each of its poles, and it empties this large tray of iron nails when they are brought sufficiently near it. On interrupting the current, the power vanishes, and the nails fall.

* Proceedings of Royal Institution, vol. iv., p. 317.

"Now the magnetized iron cannot be in all respects the same as the unmagnetized iron. Some change must take place among the molecules of the iron bar at the moment of magnetization. And one curious action which accompanies the act of magnetization I will now try to make sensible to you. Other men have labored, and we are here entering into their labors. The effect I wish to make manifest was discovered by Mr. Joule, and was subsequently examined by MM. De la Rive, Wertheim, Marian, Matteucci, and Wartmann. It is this. At the moment when the current passes through the coil surrounding the electro-magnet, a clink is heard emanating from the body of the iron, and at the moment the current ceases a clink is also heard. In fact, the acts of magnetization and demagnetization so stir the particles of the magnetized body that they, in their turn, can stir the air and send sonorous impulses to our auditory nerves.*

"The sounds occur at the moment of magnetization, and at the moment when magnetization ceases; hence, if a means be devised of making and breaking, in quick succession, the circuit through which the current flows, we shall obtain an equally quick succession of sounds. I do this by means of a contact-breaker which belongs to a Ruhmkorff's induction coil. A thin bar of iron stretches from one of the bridges of this monochord to the other. This bar is placed in a glass tube, which is surrounded by copper wire. The contact-breaker is placed in a distant room, so that you cannot hear its noise. The current is now active, and every individual in this large assembly hears something between a dry crackle and a musical sound issuing from the bar in consequence of its successive magnetization and demagnetization.

"Hitherto we have occupied ourselves with the iron which has been acted upon by the current. Let us now devote a moment's time to the examination of the current itself. This naked copper wire is quite unable to attract these iron filings; but I send a voltaic current through it; and now it grapples with the filings, and holds them round it in a thick envelope. I interrupt the current and the filings fall. Here, also, is a compact coil of

* The sound, I find, was first noticed by Mr. age —J. T., 16th June.

copper wire, which is overspun with cotton to prevent contact between the convolutions. On sending a current through the coil, a power of attraction is instantly developed, which enables it to empty this plate of iron nails.

"Thus we have magnetic action exhibited by a body which does not contain a particle of the so-called magnetic metals. The copper wire is made magnetic by the electric current. Indeed, by means of a copper wire through which a current flows, we may obtain all the effects of magnetism. A long coil is suspended before you, so as to be capable of free motion in a horizontal direction; it can move all round in a circle like an ordinary magnetic needle. At its ends I have placed two spirals of platinum wire, which the current will raise to brilliant incandescence. They are glowing now, and the suspended coil behaves in all respects like a magnetic needle. Its two ends show opposite polarities; it can be attracted and repelled by a magnet, or by a current flowing through another coil; and it is so sensitive that the action of the earth itself is capable of setting it north and south.

"There is an irresistible tendency to unification in the human mind; and, in accordance with our mental constitution, we desire to reduce phenomena which are so much alike to a common cause. Hence the conception of the celebrated Ampère that a magnet is simply an assemblage of electric currents. Round the atoms of a magnet Ampère supposed minute currents to circulate incessantly in parallel planes; round the atoms of common iron he also supposed them to circulate, but in all directions—thus neutralizing each other. The act of magnetization he supposed to consist in the rendering of the molecular currents parallel to a common plane, as they are supposed to be in a permanent magnet.

"This is the celebrated theory of molecular currents propounded by Ampère. You observe it consists in the application of conceptions obtained from sensible masses of matter to insensible or atomic masses. Let us follow out this conception to what would appear its legitimate consequences. I have said that we obtain both attractions and repulsions from electric currents; all these effects are deduced from one law, which is, that electric currents flowing in the same direction attract each other, while, when they flow in opposite directions, they repel each other. Let me illustrate this law rapidly. Before you are two flat coils facing each other, and about 8 in. apart. I send a current through both in the same direction; the coils instantly clash and cling together in virtue of their mutual attraction. I now reverse the current through one of them; and they fly a yard asunder in virtue of their mutual repulsion. And now one of them twists its suspending wire so as to turn its opposite face to the other coil; the currents are now again in the same direction, and the coils clash and cling as in the first instance. Imagine, then, our molecular currents flowing round the atoms of this iron bar in planes perpendicular to the length of the bar. From the law just enunciated we should infer the mutual attraction of those currents; and from this attraction we should be disposed to infer the shortening of the bar at the moment of magnetization. Here, for example is a coil of copper wire suspended vertically; the end of the coil dips into this little basin of mercury. From a small voltaic battery behind, I send a current through the coil, and, because it passes in the same direction through all its convolutions, they attract each other. The coil is thereby shortened; its end quits the mercury with a spark; the current ceases; the wire falls by its own gravity; the current again passes, and the wire shortens as before. Thus, you have this quick succession of brilliant* sparks produced by the shortening of the wire and the interruption of the current as it quits the mercury.

"Is it a fact, then, that an iron bar is shortened by the act of magnetization? It is not. And here, as before, we enter into the labors of other men.

"Mr. Joule was the first to prove that the bar is lengthened. Mr. Joule rendered this lengthening visible by means of a system of levers and a microscope, through which a single observer saw the action. The experiment has never, I believe, been made before a public audience; but the instrument referred to at the commencement of this lecture will, I

* Rendered brilliant by the introduction of a coil of wire and a core of soft iron into the circuit.

think, enable me to render this effect of magnetization visible to everybody present.

"Before you is an upright iron bar, 2 ft. long, firmly screwed into a solid block of wood.* Sliding on two upright brass pillars is a portion of the instrument which you see above the iron bar. The essential parts of this portion of the apparatus are, first, a vertical rod of brass, which moves freely and accurately in a long brass collar. The lower end of the brass rod rests upon the upper flat surface of the iron bar. To the top of the brass rod is attached a point of steel; and this point now presses against a plate of agate, near a pivot which forms the fulcrum of a lever. The distant end of the lever is connected, by a very fine wire, with an axis, on which is fixed a small circular mirror. If the steel point be pushed up against the agate plate, the end of the lever is raised; the axis is thereby caused to turn, and the mirror rotates. I now cast a beam from an electric lamp upon this mirror; it is reflected in a luminous sheaf, 15 or 16 ft. long, and it strikes our screen, there forming a circular patch of brilliant light. This beam is to be our index; it will move as the mirror moves, only with twice its angular velocity; and the motion of the patch of light will inform us of the lengthening and shortening of the iron bar.

"I employ two batteries, one to ignite the lamp, and the other to magnetize the iron bar. At present no current is passing. Let us make the circuit; the bright image on the screen is suddenly displaced. It moves through the distance of a foot. I break the circuit; the bar instantly shrinks to its normal length, and the image returns to its first position. However often you make the experiment the result is the same. When the bar is magnetized the image always descends, which declares the lengthening of the bar. When the current is interrupted the image immediately rises. This is the first time that this action of magnetism has been seen by a public audience.

"The same apparatus has been employed in the examination of bismuth bars; and, though considerable power has been applied, I have hitherto failed to produce any sensible effect. It was at least conceivable that complementary effects might be here exhibited, and a new antithesis thus established between magnetism and diamagnetism.

"And now for the explanation of this action. I place this large flat magnet upon the table; over it a paper screen; and on the screen I shake iron filings. You know the beautiful lines in which those filings arrange themselves—lines which have become classical from the use made of them in this institution; for they have been guiding-threads for Faraday's intelligence while exploring the most profound and intricate phenomena of magnetism. These lines indicate the direction in which a small magnetic needle sets itself when placed on any of them. The needle will always be a tangent to the magnetic curve. A little rod of iron, freely suspended, behaves exactly like the needle, and sets its longest dimension in the direction of the magnetic curve. In fact, the particles of iron filings themselves are virtually so many little rods of iron, which, when they are released from the friction of the screen by tapping, set their longest dimensions along the lines of force. Now, in this bar magnet the lines of force run along the magnet itself, and, were its particles capable of free motion, they also would set their longest dimensions parallel to the lines of force, that is to say, parallel to the length of the magnet. This, then, is the explanation given by M. de la Rive of the lengthening of the bar. The bar is composed of irregular crystalline granules; and when magnetized, these granules tend to set their longest dimensions parallel to the axis of the bar. They succeed partially, and produce a microscopic lengthening of the bar, which, suitably magnified, has been rendered visible to you. The explanation seems to me as satisfactory as it is acute.

"Let me now endeavor to render these beautiful magnetic curves visible to you all. From an electric lamp turned on its back a vertical cylinder of light issues. Over the aperture of the lamp are placed two small bar magnets, enclosed between two plates of glass. The vertical beam is received upon a looking-glass which reflects it on to the screen. In the path of this reflected beam is placed a lens,

* The wood was employed merely for lecture-room purposes; for accurate observations the iron bar was always fixed upon the block of Portland stone.—J. T, 1870.

which projects upon the screen a magnified image of the two small magnets. And now I sprinkle fine iron sand on the plate of glass, and you see how it arranges itself under the operation of the magnets. A most beautiful display of the magnetic curves is now before you. And you observe, when I tap the glass, how the particles attach themselves by their ends, and how curves close in upon each other. In the solid iron bar they also try to attach themselves thus, and close thus up; the consequence is, that the longitudinal expansion is exactly counterbalanced by the transverse contraction, so that the volume of the bar remains unchanged.

"But can we not bring a body with movable particles within an electro-magnetic coil? We can; and I will now, in conclusion, show you an experiment devised by Mr. Grove, which bears directly upon this question, but the sight of which, I believe, has hitherto been confined to Mr. Grove himself. At all events, I am not aware of its ever having been made before a large audience. This cylinder with glass ends contains a muddy liquid, the muddiness being produced by the magnetic oxide of iron which is suspended mechanically in water. Round the glass cylinder are coiled 5 or 6 layers of covered copper wire; and here is a battery from which a current can be sent through the coil. First of all I place the glass cylinder in the path of the beam from our electric lamp, and, by means of a lens, cast a magnified image of the end of the cylinder on the screen. That image at present possesses but feeble illumination. The light is almost extinguished by the suspended particles of magnetic oxide. But, if what has been stated regarding the lines of force through the bar of magnetized iron be correct, the particles of the oxide will suddenly set their longest dimensions parallel to the axis of the cylinder, and also in part set themselves end to end when the current is sent round them. More light will be thus enabled to pass; and now you observe the effect. The moment the circuit is established the disc upon the screen becomes luminous. When the current is interrupted, gloom supervenes; I re-establish it, and we have a luminous disc once more.

"The apparatus before you, was as stated, really invented to examine whether any mechanical effect of this kind could be detected in diamagnetic bodies, but hitherto without result. And this leads me to remark on the large ratio which the failures of an original inquirer bear to his successes. The public see the success; the failure is known to the inquirer alone. The encouragement of his fellow-men, it is true, often cheers the investigator and strengthens his heart; but his main trials occur when there is no one near to cheer him, and when, if he works aright, he must work for duty and not for reputation. And this is the spirit in which work has been executed in this institution, by a man who has, throughout his life, turned a deaf ear to such allurements as this age places within the reach of scientific renown; and it behooves every friend of this institution to join in the wish that that man's spirit may continue to live within its walls, and that those who come after him may not shrink from his self-denial should they ever hope to merit a portion of his fame.

"Biot found it impossible to work at his experiments on sound during the day in Paris; he was obliged to wait for the the stillness of the night. I found it almost equally difficult to make accurate experiments, requiring the telescope and scale, with the instrument just described, in London. Take a single experiment in illustration. The mirror was fixed so as to cause the cross-hair of the telescope to cut the number 727 on the scale; a cab passed while I was observing; the mirror quivered, obliterating the distinctness of the figure, and the scale slid apparently through the field of view and became stationary at 694. I went upstairs for a book; a cab passed, and on my return I found the cross-hair at 686. A heavy wagon then passed, and shook the scale down to 420. Several carriages passed subsequently; the figures on the scale were afterwards 350. In fact, so sensitive is the instrument, that long before the sound of a cab is heard its approach is heralded by the quivering of the figures on the scale.

"Various alterations which were suggested by the experiments were carried out by Mr. Becker, and the longer I worked with it the more mastery I obtained over it; but I did not work with it sufficiently long to perfect its arrange-

ments. Some of the results, however, may be stated here.

"At the beginning of a series of experiments the scale was properly fixed, and the pressure of the pointed vertical rod F, Fig. 1, on the end of the iron bar, I, so regulated as to give the mirror a convenient position; then, before the bar was magnetized, the figure cut by the cross-hair of the telescope was read off. The circuit was then established, and a new number, depending on the altered length of the bar by its magnetization, started into view. Then the circuit was interrupted, and the return of the mirror towards its primitive position was observed. The mirror, as stated, was drawn back to its first position by the spiral hair-spring shown in Fig. 1. Here are some of the results: Bar unmagnetized, figure of scale, 577; bar magnetized, 470; bar unmagnetized, 517.

"Here the magnetization of the bar produced an elongation expressed by 107 divisions of the scale, while the interruption of the circuit produced only a shrinking of 47 divisions. There was a tendency on the part of the bar, or of the mirror, to persist in the condition superinduced by the magnetism. The passing of a cab in this instance caused the scale to move from 517 to 534—that is, it made the shrinking 64 instead of 47. Tapping the bar produced the same effect.

"The bar employed here was a wrought-iron square one 1.2 in. on a side and 2 ft. long.

"The following tables will sufficiently illustrate the performance of the instrument in its present condition. In each case are given the figures observed before closing, after closing, and after interrupting the circuit. Attached to each table, also, are the lengthening produced by magnetizing and the shortening consequent on the interruption of the circuit:

Circuit.	Scale. 10 cells.	
Open	647	
Closed	516	131 elongation
Broken	581	65 return.
Open	637	
Closed	509	128 elongation
Broken	579	70 return.
Open	632	
Closed	491	141 elongation
Broken	568	77 return.

Circuit.	Scale. 20 cells.	
Open	653	
Closed	465	188 elongation
Broken	579	114 return.
Open	638	
Closed	452	186 elongation
Broken	568	116 return.
Open	632	
Closed	472	160 elongation
Broken	561	89 return.

"These constitute but a small fraction of the number of experiments actually made. There are very decided indications that the amount of elongation depends on the molecular condition of the bar. For example, a bar taken from a mass used in the manufacture of a great gun at the Mersey Ironworks suffered changes on magnetization and demagnetization considerably less than those recorded here."

The following is a summary view of the Victorian railways: A trunk line of railway runs from Melbourne to the northern boundary of the colony at Echuca; another proceeds via Geelong to Ballarat, the second town of importance; a third is about to be constructed to Beechworth, near the north-eastern boundary of Victoria; a fourth is being surveyed to Hamilton, the centre of an agricultural district in the west; and a fifth has been projected to Gipp's Land, which may be called the garden of the colony, in the south-east. When these lines are completed ready access will be obtained to the most fertile districts of the country, as well as to those which abound in mineral treasures.

The report of the directors of the Watton and Thetford Company states that they have been unable to make any satisfactory arrangements with the Great Eastern for working the line. The traffic results attained thus far have not been very encouraging, the receipts on revenue account to December 31st having been £586, while the working expenses amounted to £511, leaving a balance of £75. An Act has been passed for extending the line from Watton to Swaffham, but no steps have hitherto been taken for constructing this extension line.

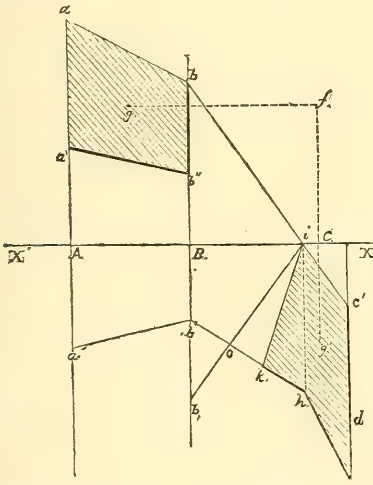
TRANSPORTATION OF EARTH.

Translated from Sonnet's "Dictionnaire des Mathématiques Appliquées."

In all constructions which require the movement of large quantities of earth, such as the establishment of a road, railroad, or canal, two questions have to be solved: one consisting of the determination of the mean distance of transport of earth, the other of the most advantageous *organization* of this transport. We shall first consider the former.

If V is the total volume necessary for a given cutting, the cost of transport is proportional to V; but it will also depend upon the distances to which the different portions of the volume V must be transported. Let v, v', v'', etc., repesent the several elements of the volume V; d, d', d'' etc., the distances corresponding to these

FIG. 1.



elements; then the expense of transport will be proportial to the quantity—

$$vd + v'd' + v''d'' +, \text{ etc.}$$

Let D be such a distance that

$$vd + v'd' + v''d'' +, \text{ etc.}, = VD; \quad [1]$$

then D will be the mean distance of transport, and the expense will be proportional to the product VD. The determination of this mean distance is important.

The most simple and ordinary case is that in which the carriage is along a straight line. In this case the mean distance is the distance between the centres of gravity of the cutting and the filling. Let χ^0, χ', χ'' .... X_0 be the primitive distances of the centres of gravity of the elementary volumes v, v', v'', and of the total volume to any fixed plane perpendicular to the axis of the route; and let χ', χ'', χ''' .... X be the distances of the same centres to the same plane after transport. Then $d = \chi - \chi_0$; $d' = \chi' - \chi_0'$; $d'' = \chi'' - \chi_0''$; .... therefore, equation [1] may be written:

$$v(\chi - \chi_0) + v'(\chi' - \chi_0') + v'' - (\chi'' - \chi_0'') + \ldots\ldots = VD;$$

or,

$$[v\chi + v'\chi' + v''\chi'' + \ldots] - [v\chi_0 + v'\chi_0' + v''\chi_0'' + \ldots] = VD.$$

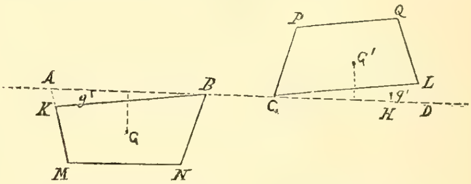
Applying the principle of moments,

$$VX - VX_0 = VD$$
$$\therefore D = X - X_0;$$

which proves the above principle.

In applying this rule, engineers generally employ a graphic method. Let X X' (Fig. 1) be the axis of the route; and A, B, C points at which the cross-sections have been determined. Suppose

FIG. 2.



that the first profile, A, presents a section of cutting, d, and a section of filling, r; the second profile, B, corresponding sections, d and r; the third, C, a filling without cutting. If, through the point of change from cutting and filling in the profile B a vertical plane is supposed to be parallel to the axis of the route, it will divide the filling of the profile C into two parts; one, ρ, corresponding to the cutting d', the other, ρ', to the filling r'. Perpendiculars are drawn to X X' at A, B, and C; A a, B b are laid off proportional to the areas of the cuttings d and d'; and A a', B b', C c', D d', proportional to the fillings r, r', ρ, ρ'. Connect by straight lines a b, a' b', b' d, and b c'. The volume of the cutting between A and B is approximately

$$\tfrac{1}{2}(d + d')\, AB,$$

and is represented by the area of the trapezoid A a b B. The volume of the filling between the same sections is repre-

sented by $A\,a'\,b'\,B$. Between the sections B and C we must first consider the volume of filling corresponding to the fillings r' and ρ'; it is represented in the drawing by the trapezoid $B\,b'\,d\,C$; we must next consider an area corresponding to the cutting d' and the filling ρ. The distance χ of the mean line of passage to the section B, being expressed by

$$\chi = BC.\frac{d'}{a'+\rho} \quad \text{or} \quad BC.\frac{Bb}{Bb+Cc'},$$

must be equal to Bi. Consequently the volume of the portion in cutting, being expressed by

$$\tfrac{1}{2}\,d'\chi \quad \text{or} \quad \tfrac{1}{2}\,Bb.Bi,$$

is represented by the area of the triangle $b\,B\,i$. The volume of filling is represented by the area of the triangle $i\,C\,c'$.

Between two consecutive sections there is a partial compensation between cutting and filling consequent upon the carriage of earth perpendicular to the axis of the route, thus requiring no longitudinal transport. By laying off the trapezoid $A\,a'\,b'\,B$ upon $A\,a''\,b''\,B$, it is seen that after the partial compensation just mentioned there will remain an excess of cutting corresponding to $a\,a''\,b\,b''$. To obtain more conveniently the total filling between B and C, which is the sum of $B\,b'\,d\,C$ and $i\,C\,c'$, draw $i\,h$ perpendicular to $X\,X'$; make $d\,e = C\,c'$, and join $e\,h$; the triangle $d\,e\,h$ is equivalent to the triangle $i\,C\,c'$, so that the total filling is shown by the polygon $B\,C\,e\,h\,b'$. Revolve the triangle $b\,B\,i$ to $b,\,B\,i$, and put for the $b'\,o\,b$, the equivalent triangle $i\,o\,k$. The figure $B\,b'\,k\,i$ is equal to $b,\,B\,i$, and the excess of the filling between B and C will therefore be represented by the figure $i\,h\,k\,e\,C$. The centres of gravity g' and g of $a\,a''\,b''\,b$ and $i\,k\,h\,e\,C$ are found. We draw $g\,f$ parallel to $X\,X'$ and $g'\,f$ perpendicular. The distance $g\,f$ is the mean distance of transport.

This method is applicable, whatever the number of profiles, by carrying from one interval to the next the excess of cutting obtained by the partial compensation made in each interval. This expeditious process gives results sufficiently approximate, especially if the drawing is made to a large scale. The centres of gravity can often be determined by inspection without great error. It is not necessary to use the same scale for distances in the direction $X\,X'$ and for the distances set off perpendicular to this axis. Ordinarily the last are taken to the scale 0m.005 per square metre; the first are taken to the scale 0m.001, 0m.002 to the metre; sometimes to a smaller scale.

There is another case in which the mean distance of transport can be evaluated very easily; that in which the cutting or filling can be divided by vertical planes into equal corresponding slices. This happens in most of the terracing work in fortification. The relief of fortified works is formed by the earth brought forward from the ditch, so that a series of vertical planes perpendicular to the direction of the *line de feu* divide the fosse and the relief into sections of the same volume. In this case the distance between the centres of gravity of cutting and filling is the same for each section; it is equal to the distance between the centres of gravity of the force and of the total relief; and this is the mean distance of transport.

In other cases this mean distance can be determined only approximately, and its minimum can be found only by *tatonnement.* In general, engineers take approximate value of the mean distance, the distance between the centres of gravity of cutting and of filling.

We have supposed the direction of transport to be horizontal. When in going from cutting to filling it is necessary to go up a rising grade, this circumstance of course increases the work. In military engineering it is assumed that 20 metres of distance on a rising grade of $\frac{1}{12}$ is equivalent to 30 metres on a horizontal; and the cost of transport is determined by this rule. Suppose b to be the horizontal projection of the distance to be passed over and h the height, the grade being 1 in 12, we have $b = 12h$; and the distance $12h$ on the rise is equal to $18h$ on the horizontal.

Let $A\,M\,N\,B$ (Fig. 2) represent the section of an excavation from which earth is to be carried to fill the section $C\,P\,Q\,D$. Through the points B and C draw the lines $B\,K$ and $C\,L$ at an incline of 1 to 12; that is, at a horizontal angle of about 4° 46′. Let g be the centre of gravity of the triangle $A\,K\,B$, g' that of the triangle $C\,L\,D$, G that of the quadrilateral $L\,M\,N\,B$, G' that of the quadrilateral $C\,P\,Q\,L$; h, h', H, H' the distances of the several centres from the horizontal $A\,B\,C\,D$; let

fall upon this horizontal the perpendiculars $g\ I$ and $g'\ H$. Consider the volumes corresponding to the same length of excavation and embankment perpendicular to the plane of the figure. Earth must be brought to the point B, carried from B to C, and spread over the entire surface of the embankment. It may be assumed that the work is the same as if the volumes were concentrated at their centres of gravity. According to this supposition, in order to bring the earth from the prism $A\ K\ B$ to B, a volume v must be moved a distance compounded of $I\ B$, horizontal distance, and $6h$, taking rise into account. The product of the volume by the distance is

$$v\ (IB + 6h)$$

while the corresponding product for carriage from B to C is

$$v.BC.$$

For transport from the point C to the several points of the prism $C\ L\ D$ of volume v', we shall have

$$v'\ (CH + 6h').$$

Let V represent the volume of the prism $K\ M\ N\ B$, and V' that of the prism $C\ P\ Q\ L$; then the product for transport to the point B is

$$V.18H;$$

from B to C the product is

$$V.BC;$$

finally, for transport from C to all points of the prism $C\ P\ Q\ L$, the product is

$$V'.18H'.$$

In order not to pass the inclination 1 in 12, the line of distribution of the volumes V and V' must be extended by making them follow the slopes made upon the interior talus of the excavation and upon the talus. These slopes are divided into lengths of 20 metres, so that each receives 10 metres of distributiom from either end. The centre of gravity of the volume received or distributed is then 5 metres from the slope. Hence 5 metres must be added to the distance of transport of each of the volumes V and V'; so that the total sum of products of volumes and distances is

$$\left.\begin{array}{c} v\ (IB + 6h + BC) + v'\ (CH + 6h') \\ + V(18H + BC + 5\text{m.}) + V'\ (18H' + 5\text{m.}) \end{array}\right\} \cdots [2]$$

This sum, divided by the total volume $v' + V'$, will give the mean distance of transport.

The first two terms of formula [2] can generally be neglected in comparison with the other two, unless either the excavation or the embankment is broad and shallow. When these terms can be neglected, we have $V = V'$, and the formula reduces to

$$V\ [18\ (H + H') + BC + 10\text{m}].;$$

the mean distance of transport in this case is

$$18\ (H + H') + BC + 10\text{m.}, \qquad [3]$$

that is, it is 18 times the difference of levels of the centres of gravity of the cutting and the filling, increased by the distance from the edge of the cutting to the foot of the filling, increased by 10 metres.

If the ground rise from B to C, H being the difference of level of the points G and B, H' that of the points G' and C, z that of the points B and C, we have for mean distance of transport

$$18\ H + BC + 6z + 18\ H' + 10\text{m.},$$

or

$$18\ (H + H') + BC + 6z + 10\text{m.},$$

which amounts to adding, according to the rule given above, 6 times the difference of level of the points B and C.

On the other hand, if the ground descend from B to C, we should apply formula [3] without taking this circumstance into account, unless the point G' does not descend a level equal to or less than that of B, in which case it is only necessary to add $18H + 10$m., the horizontal distance from the points B and G'. No account is taken of the descending slopes.

When the earth has to be removed only 2 and 4 metres in a horizontal direction, or from 1.6 to 2 metres in a vertical direction, the transport should be made with the shovel. For greater distances the wheelbarrow is used, and the carriage is done by relays; the quantity of earth is said to be *à un seul homme,* if a single laborer can load a barrow while another runs over a relay of 30 mètres, going and returning. The quantity of earth is said to be *à un homme et demi* if it is necessary to have two loaders to one digger to feed two barrows running over the same relay. The earth can be *à deux hommes*, or *à trois hommes.* In general, if T denotes the time occupied by a pickman to dig a certain volume of earth, and t the time for a loader to load the same volume upon a barrow, the ratio $\frac{T}{t}$ expresses the num-

ber of pickers necessary that a loader may work without interruption. The number necessary to supply a wheeler is

$$\frac{T}{t}+1 \text{ or } \frac{T+t}{t}$$

and the quantity of earth is said to be to

$$\frac{T+t}{t} \text{ men.}$$

As to the length of the relay, it is determined by the following considerations: It is assumed that a wheeler can run 30,000 metres in a day of 10 hours, and that a loader can load 20 cubic metres in the same time. The ordinary capacity of a barrow is 0m.04; *i. e.*, 25 barrows to the cubic metre. If χ denotes the distance run by the wheeler while the loader fills a barrow, we have

$$20 : 0.04 :: 30000\text{m.} : \chi$$
$$\chi = 60\text{m.}$$

The half of this distance, 30 metres, is the length of the relay. This is about the same in all localities, while the capacity of the barrow varies, according to the country, from $\frac{1}{33}$d to $\frac{1}{20}$th of a cubic metre. It is desirable to know the time necessary to transport a cubic metre the distance of a relay. As the wheeler runs 3,000 metres an hour, he wheels a double relay of 60 metres in 0h.02; but in this time he carries $\frac{1}{25}$th of a cubic metre; to carry a cubic metre a distance of 30 metres, he will require a time

$$0\text{h}.02 \times 25 \text{ or } 0\text{h}.50$$

For longer distances the hand-truck *(camion)*, dumping cart *(tombereau)*, or wagon *(wagon de terrassement)* is used. The hand-truck has a capacity of 20 cubic metres, and is usually drawn by men. The relays are about 100 metres, or it requires 20 minutes to carry a cubic metre over this distance. The capacity of the dumping carts varies from 0.50 to 1.50 cubic metres; it is drawn by one or by two horses. About 20 minutes are employed in moving a cubic metre over a distance of 100 metres, by means of a cart of mean capacity, loading and unloading included.

For longer distances, wagons (or carts) are employed, drawn by horses or a locomotive, and the transport is not made in relays. At Clamart, on the Versailles Railway, the wagons had a capacity of 1.50 metres. Three horses dragged 10 of these, with a velocity of 25,000 metres, in 10 hours. A locomotive dragged 20 with four times this velocity. In each case there was a loss of 10 minutes each trip for loading and unloading. The road had an inclination of 0m.004 to the metre. On a horizontal road five horses instead of three would have been necessary.

The barrow or the truck is generally employed for distances of less than 100 metres; the dumping-cart for distances from 100 to 500 metres; wagons drawn by horses, from 500 to 2,000 metres, and for greater distances, cars drawn by a locomotive. In mountainous countries the earth is often carried on the back of a laborer or a mule; in the first case panniers are used, of a capacity of about 0m.01; in the latter case each pannier has a capacity of about 0m.04.

When earth has to be moved in a vertical direction, the shovel should be employed, if possible, for heights not exceeding 1m.65. The laborers, one above the other, at this interval, can raise, in 10 hours, 15 cubic metres to a height of about 5 metres. Another method, almost as good, is carriage by the basket, by aid of a ladder. A laborer can make 27 trips of 3 metres height in an hour, carrying in all 8.10 cubic metres a distance of 3 metres—a result nearly equivalent to the former; for, multiplying the volume by the height, we have in the first case 72.9; in the second, 75.

Sometimes panniers, called *bourriquets*, are raised by a drum. The capacity of one of these is 0.033 cubic metres. The drum is from 15 to 20 centimetres in diameter, and from 1m. to 1m.2 in length. The crank is 0m.4 long. The rope which carriers the panniers is 0.03m. in diameter. By means of this apparatus, 15 cubic metres can be raised to a height of 5 metres. A similar method is employed in tunnelling work.

THE Magdeburg Lansitzer (Prussian) Railway have issued a prospectus, inviting subscriptions for 8,000,000 thalers, or £1,200,000, less 3,000,000 thalers, or £450,000, which has already been locally subscribed. The line is 106 miles in length, and is projected to complete a link much wanted to facilitate direct communication between East and West Prussia, so as to avoid the necessity of passing round by Berlin.

THE PROJECTED CHANNEL RAILWAYS.

From "Nature."

We have already considered two modes of crossing the English Channel by a railway, viz., one above the water by a bridge, and another below the water by a tunnel through the chalk. The two shores might be also connected by a submerged roadway passing direct through the water. It might be constructed either on the bottom of the Channel or at a certain distance below the level of the sea. Submerged roadways have been proposed, some of iron, others of concrete ; of the former of these we shall only consider such schemes as appear to have received sufficient attention from their originators.

These structures may be simply called tubes, because of their circular shape, which is, we all know, the most favorable form to resist pressure against collapse. The various propositions for the construction of iron tubes may be divided in two classes, viz. : 1st, Schemes in which the parts of the proposed submerged tube are to be constructed on shore in certain lengths, afterwards to be united under water to form the permanent structure. 2d, Schemes in which the whole tube is to be at once built in deep water.

Among the designs which belong to the first class, the best and most elaborate is that of the late Mr. Chalmers. His design is well known from his publication on the Channel Railway, which we consider a meritorious and ingenious production. He proposes a line of tube between the South Foreland and Blanc-Nez on the French coast, with a gigantic tower—or ventilator, as he terms it—midway in the Channel in 30 fathoms of water. Having made this tower, he proposes to construct wrought-iron tubes on shore, each about 400 ft. long, closed at both ends by water-tight bulkheads. These tubes are to be floated, one by one, to the tower, and to be there submerged, "being drawn down by means of endless chains passing round pulleys or drums attached to massive anchor boxes on the bottom of the Channel." The separate parts to be submerged at one operation are to have each a floating-power equal to about 100 tons. A short description is also given how the ends of the tube about to be submerged should be drawn and attached to that part already permanently secured to the tower and the bottom of the Channel.

The deep sea tower or ventilator is probably not practicable, but we consider it does not form an essential part of the scheme. The whole tube might be formed of 240 separate pieces, each 400 ft. long, and submerged without the tower by working from one shore end. The submerging and joining together of these parts in deep water would, however, be a perilous operation. No doubt this is the main difficulty of every plan of this class of scheme. In the present case it must be overcome and the operation 240 times successfully repeated, in order to complete the structure, and we may accordingly appreciate the chance in favor of the completion of this kind of submerged roadway.

Of the second class of works, viz., building the whole tube in deep water, we have but one scheme. It is the more satisfactory to observe that, of all the schemes which have been proposed with a view to establish a permanent railway communication between England and France, it is the most elaborate and complete, offering a solution on all material points in connection with this subject. The authors of this project—Messrs. Bateman and Révy—have published a full account of their scheme, and we cannot do better than refer to their work for a short description of the plan they adopt.

"Our object has been to devise a scheme by which all difficulties of operating in water should be avoided. We propose to lay a tube of cast-iron on the bottom of the sea, between coast and coast, to be commenced on one side of the Channel, and to be built up within the inside of a horizontal cylinder, or bell, or chamber, which shall be constantly pushed forward as the building up of the tube proceeds. The bell or chamber within which the tube is to be constructed will be about 80 ft. in length, 18 ft. internal diameter, and composed of cast-iron rings 8 in. thick, securely bolted together. The interior of the bell will be bored out to a true cylindrical surface, like the inside of a steam cylinder. The tube to be constructed within it will consist of cast-iron plates in segments 4

in. in thickness, connected by flanges, bolted together inside the tube, leaving a clear diameter of 13 ft. when finished. Surrounding this tube and forming part of it, will be constructed annular discs or diaphragms, the outside circumference of which will accurately fit the interior of the bell. These diaphragms will be furnished with arrangements for making perfectly water-tight joints for the purpose of excluding sea water and securing a dry chamber, within which the various operations for building up the tube, and for pressing forward the bell as each ring of the tube is added, will be performed. Within this chamber, powerful hydraulic presses, using the built and completed portion of the tube as a fulcrum, will, as each ring is completed, push forward the bell to a sufficient distance to admit the addition of another ring to the tube. The bell will slide over the water-tight joints described, one of which will be left behind as the bell is projected forward, leaving three always in operation against the sea. The weight of the bell and of the machinery within it will be a little in excess of the weight of water displaced, and therefore the only resistance to be overcome by the hydraulic presses when pushing forward the bell, is the friction due to the slight difference in weight and the head or column of water pressing upon the sectional area of the bell against its forward motion. In like manner, the specific gravity of the tube will be a little in excess of the weight of water which it displaces; and in order to obtain a firm footing upon the bottom of the sea, the tube will be weighted by a lining of brick in cement, and for its further protection will be tied to the ground by screw piles, which will pass through stuffing boxes in the bottom of the tube. These piles, will, during the construction of the tube within the bell chamber, be introduced in the annular space between the outside of the tube and the inside of the bell, and will be screwed into the ground as they are left behind by the progression of the bell. The hydraulic presses and the other hydraulic machinery, which will be employed for lifting and fixing the various segments of the tube, will be supplied with the power required for working them from accumulators on shore, on Sir William Armstrong's system, and the supply of fresh air required for the sustenance of the workmen employed within the bell and within the tube will be insured also by steam power on shore. As the tube is completed, the rails will be laid within it for the trains of wagons to be employed in bringing up segments of the rings as they may be required for the constructions of the tube, and for taking back the waste water from the hydraulic presses, or any water from leakage during the construction.

The tube will be formed of rings of 10 ft. in length, each ring consisting of 6 segments, all precisely alike, turned and faced at the flanges or joints, and fitted together on shore previous to being taken into the bell, so that on their arrival the segments may, with perfect certainty and precision, be attached to each other. The building of the tube will be commenced on dry land above the level of the sea, and will be gradually submerged as the tube lengthens. The operations on dry land will be attended with more difficulty than those under water, but all these circumstances have been carefully considered and provided for.

The precise line to be taken betwixt the English and French coasts can hardly be determined without a more minute survey of the bottom of the Channel than at present exists. It will probably be between a point in close proximity to Dover on the English coast, and a point in close proximity to Cape Grisnez on the French coast. On the line suggested the water increases in depth on both sides of the Channel more rapidly than elsewhere, although in no instance will the gradient be more than about 1 in 100. The tube at each end would gradually emerge from the water, and on arriving above the level of the sea would be connected with the existing railway systems, so that the same carriage may travel all the way from London to Paris, or, if Captain Tyler's anticipation be realized, all the way from John O'Groat's to Bombay.

The distance across the Channel on the line chosen is about 22 miles. The tube as proposed is large enough for the passage of carriages of the present ordinary construction, and to avoid the objections to the use of locomotives in a tube of so great a length, and the nuisance which would be thereby created, and taking advantage of the perfect circular form which the mechanical operation of turning, facing, etc., will insure, it is proposed

to work the traffic by pneumatic pressure. The air will be exhausted on one side of the train and forced in on the other, and so the required difference of pressure will be given for carrying the train through at any determined speed. Powerful steam-engines, with the necessary apparatus for exhausting and forcing the air into the tube, will be erected on shore at each end; and supposing one tube only to exist, the traffic will be worked alternately in each direction.

It has been found by calculation, that, for moving a large amount of tonnage and a great number of passengers, the most economical arrangement will be to send combined goods and passenger trains through the tube at 20 miles an hour, with occasional express trains at 30 miles an hour. Thus an ordinary or slow train would occupy about 66 minutes in the transit, and a quick or express train about 45 minutes. In this way the tube, if fully worked, would permit the passage of 16 ordinary slow trains (8 each way), and 6 express trains (3 each way), each conveying both goods and passengers. About 10,000 tons of goods per day, or upwards of 3,000,000 per annum, and 5,000 passengers, or nearly 2,000,000 per annum, might be taken through, or a less amount of goods and a larger number of passengers, or *vice versa*, if circumstances rendered other proportions necessary or desirable.

The horse power required for working the traffic with the above number of ordinary and express trains will be, on the average, 1,750 indicated, or about 400 nominal horse power at each end."

We should gladly have referred to many other interesting and important statements contained in this work, but our limited space does not admit of our doing so. A general idea of the proposition may be gathered from the above description of the authors, taken from the popular part of their work. The Appendix, which really contains the substance of the scheme, is too elaborate and technical for the general reader, without devoting special study and attention to it. Suffice it to state, that the amount of information conveyed in those 40 pages of close print is very great, being an account of a succession of results of elaborate investigations of a physical, mathematical, and even of a chemical nature. One gains confidence from the mere fact, that in treating the subject the authors are evidently "at home," and do not evade a difficulty.

The general principle of the scheme, as invented and elaborated by Messrs. Bateman and Révy, may be easily understood by the ordinary reader. He can, however, have little idea how the practical difficulties attending the execution of such immense works have been overcome by these engineers. Take, for example, the first sentence or two we have quoted above. The general proposition is this: "A tube of cast-iron to be built up inside a horizontal cylinder or chamber." No doubt this may appear simple enough, but when we come to consider what the operation of *building* means; when we come to consider that no part of the tube to be so built up weighs in one piece less than 10 tons; that those solid pieces of iron could not even be stirred by the power of scores of men, much less lifted or deposited in the right place; that this "building up" is to take place in a comparatively small space, not exceeding 13 ft. in diameter, the larger part of which is already occupied by the very plate weighing 10 tons,—we may in a measure realize what the word "building" under these circumstances signifies.

But we have further to bear in mind, that it is not enough that we should be able somehow to "build up" the tube inside that chamber, but that it must be done quickly, without delay or a hitch, and that unless it could be so done the operation of "building up" would take generations in crossing the Channel, and make the whole proposition, though practicable in every detail, yet a forlorn hope, because of the length of time. If thus we come to consider, that the authors have not contented themselves with saying that "their tube is to be built up in that chamber," but have given us the precise designs and the exact mode of proceeding to be adopted; that the designs and arangements are so complete that they might be forthwith placed in the hands of a contractor; that these mechanical arrangements would enable a boy of ordinary intelligence to take hold, lift, and place, and finally deposit these monster plates with the same ease, quickness, and certainty as a bricklayer would lay his brick in the construction of an

arch, we venture to say the authors have made out their case.

We believe it is the first time that any of the projectors or designers of Channel railways have paid serious attention to the important question, how such a submerged railway or tunnel could be used and worked to advantage for the enormous traffic between England and France. Most of them seem to assume, as a matter of course, that such a tunnel of iron or brick would be worked as ordinary railways. It appears, however, from in the investgations of Messrs. Bateman and Révy that there is but one way of working such a tunnel to advantage, and unless the arrangements and the construction of the works be kept in accordance with that mode of working the traffic, the tunnel, when completed, would be of no use for practical purposes. The authors find that the power for the propulsion of the trains must be pneumatic pressure ; not as applied in the old-fashioned style above ground, and known by the name of atmospheric railways, but a pressure of air applied by powerful pumps directly upon the train, which would form a kind of loose piston inside the tube. On the old plan, the train was outside a little tube ; on the new plan, the train is inside a large tube ; and with this simple alteration all the difficulties which led to the abandonment of the former, disappear on the latter plan. The difficulties of the old atmospheric railways were : (1) Mechanical difficulty of connecting the piston of the little tube with the train outside it ; (2) The high pressure required on the small area of the piston for the propulsion of the train, and consequent development of an excessive amount of heat within the pumps, leading to their rapid destruction and great loss of power by subsequent cooling of the air. By the new mode of atmospheric propulsion all these difficulties are done away with, for there is no connection between a piston and the train wanted, and the pressure of the air over the large sectional area of the tube required for propulsion is but a small fraction of that formerly employed ; there is, consequently, no heating, no inordinate wear and tear, and no loss of power. Equally ingenious is the construction of the proposed air-pumps. Very large volumes of air are wanted to accompany and press forward the train—several hundred thousand cubic feet per minute. And what is the nature of the pumps to supply these ? Are they to be blast engines ? No ; they are to be air-pumps, in the shape of gasometers. We are all familiar enough with the sight of gasometers, but their application for such a purpose is certainly new.

We find throughout the work the same invincible spirit which seems to seek a difficulty for its immediate destruction. That a permanent railway across the English Channel will be built, we doubt not ; we are equally confident that Messrs. Bateman and Révy's scheme is a practicable solution of the problem. No less an authority than the Emperor Napoleon III., after mature consideration of the scheme, wrote to say : "*C'est le seul realisable,*" and as the design is one that belongs essentially to England, His Majesty's opinion acquires enhanced value and importance. Let us, then, hope that the engineering and enterprising power of this eminently engineering country will heartily support, advance, and improve the plan, which seems to insure inestimable advantages to England and France.

STEAM LIFESHIP.—Captain Hans Busk exhibited at the *conversazione* of the Royal Society on the 5th inst. a model of a steam lifeship, which he offers as likely to render good service where the lifeboat fails. The lifeship, with a crew of 30 men, is to keep the sea, and in case of falling in with a vessel in distress would render assistance from the windward, which would be easier and often more effectual than when borne from the leeward in the teeth of a gale by a lifeboat. The lifeship could "warp down" a boat to a helpless vessel, or, approaching near and dropping anchor, could fire a rocket and send a line with the wind, and so establish communication.

LARGE quantities of bittern containing bromine are allowed to run to waste at the salt works in the valley of the Saginaw, in Michigan. This fact suggests a profitable industry for some one who can devise a convenient mode of extracting this valuable element.

STEAM POWER IN MILLS.

From "Engineering."

We have on several occasions lately protested against the employment, in mills and other situations where steam-power is permanently required, of steam engines and boilers of faulty design ; and we have pointed out how—even in establishments of moderate size—the use of such engines leads to the wasteful expenditure annually of sums which, if allowed to accumulate at interest, would in a few years reach enormous amounts. Early in the present year, also, in an article entitled "The Cost of Steam Power," we gave a general outline of the matters which should be taken into consideration in choosing an engine for any given work; and on this subject we propose to say a few more words here, our remarks being especially intended to apply to the case of mills where spinning or similar operations are carried on.

In such mills, a matter of even greater importance then economy of fuel is a motion as perfectly regular as possible, and this requirement has indirectly exercised an important influence upon the economical working of mill engines. Until within the last few years almost the only form of engine to be found in such mills as those of which we are now speaking was the beam engine ; a form of engine quite unfitted for running at any but at a very moderate speed, and which, therefore, if of the single cylinder class, could not—unless fitted with an enormously heavy fly-wheel—be worked at anything like a high degree of expansion without producing an objectionable irregularity of motion. In this respect, as in many others, the compound beam engine possesses a decided advantage over the single cylinder engine for mill purposes, and we are not surprised to find that the practice originated by McNaught, of "compounding" single cylinder beam engines by the addition of a high-pressure cylinder is every day gaining ground in our manufacturing districts. The manner in which the "compounding"—as it is generally called —is carried out, varies considerably. In the majority of instances, probably, the high pressure-cylinder is placed between the main centre and the crank shaft on McNaught's original plan ; but in many instances, a horizontal high-pressure cylinder is placed by the side of the existing low-pressure one, the piston of the high-pressure cylinder deing coupled by a connecting rod to an independent crank on the crank shaft of the original engine. Mr. John Ramsbottom, of Leeds, also has "compounded" a number of engines by substituting for the existing single cylinder a group of three cylinders, placed side by side ; the two outer ones, which are of smaller diameter than the other, being the high-pressure, and the central one the low-pressure cylinder. In this arrangement, which is a very neat one, the three piston rods are attached to one crosshead, which is coupled to the parallel motion in the usual way. In connection with this arrangement of cylinders, Mr. Ramsbottom uses a peculiar form of valve, of which we may have something to say at some future time, but which we cannot describe here. When McNaught's arrangement is employed, or when a horizontal high-pressure cylinder is used in connection with the beam engine, there is of course a considerable loss of effect due to the length of the passages connecting the high and low pressure cylinders ; but, notwithstanding this loss, the practice of "compounding" has, by rendering permissible the employment of higher pressures of steam and greater expansion, effected an important economy in the vast majority of instances in which it has been resorted to ; while, in cases where it has not been successful, the failure has in almost every instance been due to the faulty manner in which the principle has been carried out. We heard of an instance a few weeks ago, where it was complained that no good had resulted from the "compounding" of a beam engine, and where it turned out, on inquiry, that the high-pressure cylinder had been made of the same capacity as the existing low-pressure one! We tru t, however, that there are few such cases as this.

At best, however, the beam engine is but a clumsy machine, and it is being rapidly supplanted for all purposes by direct-acting engines of the vertical or horizontal classes. Where only a small power is required, it is in many instances difficult

to choose between the two varieties last mentioned; but in the case of large powers, the horizontal engine possesses many advantages which render it superior to every other form. As compared with the beam engine, it is of less first cost, requires less expensive foundations and engine house, and can be run at a greatly higher speed, while, if properly constructed, it is at least equally durable. The time was when mill-owners had a strong prejudice against horizontal engines, but this prejudice is rapidly dying out, and we feel sure that but few years will elapse before such engines are used to the exclusion of almost all others for mill purposes.

The high speed at which well constructed horizontal engines can be safely driven renders it possible to work them with a high degree of expansion, even if they have but a single cylinder, without producing any great irregularity of motion; but where that regularity is of such vast importance as it is in the mills of which we are now speaking, the compound horizontal engines undoubtedly give the best results, while there is also good evidence to be had of their highly economical working. Amongst the firms who have adopted such engines as these, and who have become convinced of their advantages, we may mention here Messrs. John Crossley & Sons (Limited), of Halifax. Messrs. Crossley are well known, not merely from the high position they hold amongst our manufacturers of textile fabrics, but also from the munificent charities of the senior partners in the firm, and they rank amongst the largest employers of steam power in the kingdom. Besides their principal establishment—the Dean Clough Mills, Halifax, where nearly 5,000 hands are employed—they are the owners of the Albion and New Bank Mills at the same place, and of the Holmfield, the Shay-lane and the Dapper Mills in its immediate neighborhood; and, according to their latest returns, when we visited their mills a few weeks ago, the aggregate power of the engines at these mills amounted to 3,369 indicated horse power. Of this vast power no less than 2,287-horse power was being utilized at the Dean Clough Mills alone, while another engine, intended to indicate between 700 and 800 horse power, is in course of erection at the same establishment. Like the majority of other large mill owners, Messrs. Crossley, until within the last few years, employed beam engines exclusively, and as it happened all their engines were of the single cylinder type. About three years ago, however, they commenced to "compound" their engines, and at the present time the engines at the Shay-lane, the Holmfield and the Dapper Mills, as well as a pair of beam engines at the Dean Clough Mills, have been thus altered. The remaining engines at the latter mills are a pair of beam engines, which are now being "compounded" on McNaught's plan, by Messrs. Pollit & Wigzell, of Sowerby Bridge, and which will shortly be worked with Howard's boilers at 140 lbs. pressure; and a pair of compound horizontal engines, with cylinders $20\frac{1}{2}$ in. and 41 in. diameter respectively, the stroke being 5 ft. These latter are run at a speed of 48 revolutions, or 480 ft. of piston per minute, and at the time of our visit were indicating 826-horse power.

So far, we have spoken of the engines only, but it is in the pressure of steam which Messrs. Crossley are employing to work some of their engines that their practice is particularly distinguished. It is not so very long since 30 lbs. per square inch was thought a high pressure of steam to use in mills; but of late years pressures of 50 lbs., 60 lbs., and even 70 lbs. per square inch have become common. Messrs. Crossley, however, have made a great advance on this, and the steam for their engines at the Shay-lane and Dapper Mills is being supplied at 140 lbs. per square inch, while two boilers at the Dean Clough Mill are being worked at the same pressure. Of course no boiler of the ordinary Lancashire pattern could be worked at such a pressure as this, and to enable them to use such pressures, and at the same time obtain perfect safety, Messrs. Crossley resolved to use the well-known Howard safety boiler. Accordingly, about two years ago they put down a boiler of this kind at their Dean Clough Mill, and, its performance proving eminently satisfactory, the boilers at the Dapper and Shay-lane Mills were replaced by Howard boilers, and another of the same class was started at Dean Clough. The more extended experience with the Howard boilers bearing out that originally obtained, Messrs. Crossley are now adopting these boilers still more largely, and, in addition to the six already men-

tioned, Messrs. Howard have on order and are erecting nine others at Dean Clough, all of 50-horse power each, while they are expecting orders for nine more to replace existing boilers at the same mill. The boiler first erected by Messrs. Howard at Dean Clough was about twelve months ago tested against one of the Lancashire boilers at the same mill, and the results obtained are worth noting. The Lancashire boiler was 30 ft. long, 7 ft. in diameter, and had two 2 ft. 9 in. flues. It was fired by a Juckes's grate arranged beneath it, the grate area being 26 sq. ft., while it had a total heating surface about 900 sq. ft., or—reckoning two-thirds of the internal and half the outside flue surface as effective—an effective surface of about 600 sq. ft. The Howard boiler, on the other hand, consists of eight bottom tubes, 10 in. in diameter by about 11 ft. long, and 104 vertical tubes, 7 in. in diameter and 5 ft. long, these tubes being disposed in eight rows. The fire-grate, which has an area of 30 sq. ft., is disposed beneath the horizontal tubes. The water level is about 2 ft. from the top of the vertical tubes, and the total surface exposed to the fire and the hot gases is 1,063 sq. ft., of which 381 sq. ft. is superheating surface. Reckoning half the vertical surface as "effective," the total of the effective heating and superheating surface is 587 sq. ft.

In the trial the Howard boiler was worked for $10\frac{1}{2}$ hours, and during that time 49,300 lbs. of water were evaporated by the consumption of 6,944 lbs. of coals, 7.009 lbs. of water being thus evaporated per pound of coal. The trial of the Lancashire boiler, with Jukes's grate, lasted 63 hours, and during that time 222,900 lbs. of water were evaporated by 37,804 lbs. of coal, the evaporation being thus at the rate of 6.4 lbs. of water per pound of coal. The coal used in each case was weighed, and the water carefully measured; the description of coal used, namely, Sharlston, in the two experiments was identical, but the Lancashire boiler had the advantage of being fed with water which had been passed through a Green's "economizer," and which, in consequence, entered it at a temperature of 160 deg., while the Howard boiler was supplied with cold feed, a disadvantage which would reduce its performance quite 8 per cent. Notwithstanding this, it gave, not only a higher evaporative efficiency, but it evaporated a greater quantity of water per square foot of heating surface, as the following analysis of the results will show:

	Howard boiler. lbs.	Lancashire boiler. lbs.
Water evaporated per pound of coal	7.009	6.4
Water evaporated per hour	4695	3395
Water evaporated per hour per square foot of total heating surface	4.416	3.77
Water evaporated per hour per square foot of effective heating surface	8.0	5.77

In the above data the superheating surface of the Howard boiler has been included as part of its heating surface. If, however, we exclude this superheating surface the evaporation per square foot of effective surface would be raised to 11.85 lbs. per hour. The superior evaporative power of the Howard boiler was no doubt due to the excellence of its circulation, and to the consequent freedom of the heating surfaces from scale. Indeed, one of the tubes from the very boiler in which the above experiments were made was taken out last week for examination, after having been in use two years, and it was found perfectly free from incrustation. Considering that the water at Dean Clough is far from being of good quality, and that it is found to form a very hard deposit in the Lancashire boiler, this result is worth noting.

It is not our intention to write here of the Howard boiler, but the results which have been obtained with it at Messrs. Crossley's mills bear so directly upon the subject to which this article relates, that we feel compelled to notice them. We have spoken of the benefits to be derived from "compounding" engines, and in the practice at Messrs. Crossley's mills there is to be found not merely evidence of this benefit, but also of the additional advantage of working such compound engines with steam at an unusually high pressure. Thus the machinery at the Shay-lane and Holmfield Mills is in each case driven by a beam engine compounded on the McNaught plan, the two engines being of identical construction. In the case of the Shay-lane Mill, however, the steam is supplied to the engine at 140 lbs. pressure by one of a pair of 50-horse Howard boilers, while at the Holmfield Mill the

steam is supplied to the engine at a pressure of 70 lbs. per square inch by boilers of the Lancashire class. In the Shay-lane engine the high-pressure cylinder is 16 in. in diameter, with 3 ft. 3 in. stroke, and the low-pressure cylinder 37 in. in diameter, with 6 ft. 6 in. stroke, the relative capacities being thus as 1 to 10.7; while at the Holmfield Mill the high-pressure is made larger in proportion to the low-pressure cylinder, on account of the lower pressure of steam with which it is supplied. In January last, a careful trial of the engine at Shay-lane showed that the consumption of fuel was 2.5 lbs. per indicated horse power per hour, the trial lasting $10\frac{1}{2}$ hours, and the rakings of the fire at the end of the day being included in the quantity of fuel used. The coal employed on this occasion was local slack. In February, another trial was made with the same engine, the coal employed being "Denaby main best," and in this case the consumption of fuel was 1.894 lbs. per indicated horse power per hour, the trial lasting 10 hours, and the rakings from the fire in this instance not being included in the amount burnt. The engine on each occasion indicated 171-horse power, and the trials were made in the course of ordinary working without any arrangements for attaining special results. On the other hand, the engine at the Holmfield Mill, tried under similar circumstances, has been found to use just under 3 lbs. per indicated horse power per hour, and as the two engines are of the same construction, and the difference is too great to be accounted for by the difference in the evaporative efficiency of the respective boilers, it must be in the main ascribed to the higher pressure of steam employed at Shay-lane and to the greater extent to which expansion can consequently be profitably carried on at that mill. It is also worthy of notice that at Shay-lane an important economy of fuel was at one time found to be effected by reheating the steam on its way from the high to the low-pressure cylinder, by passing it through a steam jacketed pipe. This result was due to the fact that the feed was supplied from the waste water from the soap works in the neighborhood, thus causing the boiler to prime. Since the boiler has been supplied with pure water the priming has ceased, and the use of the superheating arrangement just mentioned has been discontinued, as, now that the steam is pure and dry, its employment has been found to produce no sensible effect on the fuel account. In fact, the steam supplied by the Howard boiler is already slightly superheated.

Altogether, the results obtained at Messrs. Crossley's various mills point undoubtedly to the same conclusion as those we have advocated, namely, that the compound engine supplied with steam at a high pressure is the most economical for mill purposes, and their experience, moreover, proves that the horizontal form of engine is not only of considerably less first cost, but can be maintained with certainty at as low an expenditure as the beam engine. Of the new horizontal engine which is now being erected at the Dean Clough Mills, by Messrs. Pollit & Wigzell, of Sowerby Bridge, from the designs of Mr. Richard Hanson, Messrs. Crossley's engineer, we propose shortly to publish engravings; but we may, nevertheless, give some particulars of it here. The high and low-pressure cylinders and the air pump are placed in a line, one behind the other, the two cylinders being respectively 15 in. and 45 in. in diameter, with 4 ft. stroke. The engine is to be run at 75 revolutions, or 600 ft. of piston per minute, and it is to indicate about 500-horse power at present, which will no doubt be about the most economical load; but it is to work up to 800-horse power when required. The steam will be supplied at a pressure of 140 lbs. per square inch, by three Howard boilers, these boilers only occupying a space of 25 ft. by 17 ft., these dimensions including the brick-work setting. This engine will, we understand, be started in the course of a week or so, and we hope that when we publish the description of it, we shall be able to give an account of its performance also.

A new route has been projected to India, which it is believed will be a formidable rival to that *via* Brindisi. A railway is to be built connecting the Austrian lines with the harbor of Santi Quaranta, in Epirus, *via* Dalmatia, Bosnia, and Albania. It is stated that this harbor could be made to hold a sufficiently large number of ships for the purpose, and that the country in its vicinity is capable of affording a great opening for its commercial development.

THE MORSE BATHOMETER.*

This is an instrument designed to aid submarine telegraphy exhibited by Sidney E. Morse and G. Livingston Morse, of New York. In regard to this bathometer the pertinent remarks of C. W. Siemens upon the apparatus in the Exhibition, in England, of 1862, may be quoted. He says: "New discoveries and inventions, represented most likely by some ill-executed model, will naturally occupy only a modest position among the great crowd of brilliant objects surrounding us at a great exhibition, and are overlooked or only half appreciated, until their real worth becomes gradually apparent, in the course of years, through the results they are destined to produce." This it is believed very aptly applies in the present case. The instrument referred to attracted little attention, from its unpretending size and appearance, and the jurors who examined it evidently misapprehended or overlooked its peculiarities. Its main principle was supposed to be the compression of air, which experience has long since proved cannot be successfully used as a means of ascertaining the depth of very deep water, and this erroneous impression probably turned away the attention of the jurors from the novel contrivances in this curious instrument.

The Morse bathometer is a double bathometer, by which the depth of the water in the deepest parts of the ocean may be ascertained, at one sounding, by two entirely distinct and independent methods. Messrs. Morse, in the course of their experiments, made the remarkable and, in its applications to investigations of the bottom of the sea, inestimably important discovery that small hollow glass spheres can be constructed which will retain their buoyancy in the deepest parts of the ocean, being neither crushed nor permeated by water under the enormous pressure at those great depths. They have made hollow glass spheres so light that they would float in water with more than half of their bulk above the surface, the spheres being between 3 and 4 in. in diameter, and the glass less than $\frac{1}{10}$ of an in. thick, and they subjected these light and fragile bodies, in the cistern of an hydraulic press, to a pressure of 7 tons on the square in., which is the pressure at the depth of about 30,000 ft., or nearly 6 miles in the ocean. The spheres came out from this severe trial of their strength and impermeability whole, and empty of everything but air. In the construction of their bathometer Messrs. Morse deposit these spheres, in any required number, in a tube of tin, wood, or other suitable material, the tube being commonly of 4 in. interior diameter, several ft. long, ballasted at its lower end so that it will stand and float upright in the water, and surmounted at the upper end by a conical or parabaloidal cap, having a socket on the top, in which a very light straight rod of any desired length may be securely fastened. When a sounding is to be made, an elongated weight, sufficiently heavy to carry the whole instrument rapidly down, is attached to the lower end of this upright, ballasted tube, and so attached that the moment a small weight, which moves in advance, strikes the bottom of the sea, the large weight will be infallibly detached and allow the tube, by its own buoyancy, to ascend with the rest of the apparatus to the surface. As this instrument is not encumbered with a line, or with anything causing irregularity of motion, it moves through the water with uniform velocity, both in its descent and ascent, and the time of its disappearance below the surface may, therefore, be taken as a correct measure of the depth of the water. If, for example, it should be found to occupy just 10 minutes in descending to and ascending from a depth of 1,000 fathoms, its disappearance for just 20 minutes would indicate that the depth was 2,000 fathoms. The rapidity of the descent and of the ascent of each instrument will be regulated, of course, by the amount of weight suspended from, and of buoyancy inclosed in, the tube. It can easily be made to go down and return in very deep water in less than a tenth part of the time required when a line is used.

But this bathometer, as has already been remarked, is double. In determining the depth of the water at any point,

* From the Report of Prof. S. F. B. Morse, LL.D., U. S. Commissioner to the Paris Exposition.

Messrs. Morse do not confine themselves to calculations based on the interval of time elapsing between the disappearance and reappearance of their instrument at the surface. They inclose in any convenient part of their tube, to be carried down and brought back with it, another instrument, which enables them, on its return to the surface, to mark, with the greatest precision, the true depth of the sea at the place of the sounding. This instrument, which is based on the principle of the compression of water, and is the proper Morse bathometer, is thus constructed. A glass bottle (it may be of the capacity of a pint, more or less) is completely filled with freshly distilled water, and closed at its neck with an india-rubber stopper. Through the centre of this stopper passes, longitudinally, a short glass tube of very small bore, open at both ends, and extending beyond the stopper in both directions, namely, an inch or more within the bottle and 2 or 3 in. on the outside. One end of an india-rubber tube 3 or 4 in. long, open at both ends, and, when open, of about an inch in diameter, is then passed over the neck of the bottle and made tight there by winding around it fine wire or cord, which presses it close to the glass. The bottle is then sunk in a vessel of distilled water till the water rises above the mouth of the india-rubber tube, which is held upon and open to receive it. Mercury, sufficient to fill the tube to the extent of one-half or more of its capacity, is then poured in, the mouth of the tube closed, and a cord or wire wound tightly around at the end, under water, thus converting the india-rubber tube into a bag filled in nearly equal portions with mercury and distilled water. On inverting the bottle, the mercury, from its specific gravity, occupies the lower half of the india-rubber bag and keeps the water from access to the lower orifice of the glass tube, which passes now from the bottom of the bag through the stopper into the bottle. When this bottle of water, thus prepared, is placed at the bottom of the sea, the pressure of the external sea water, acting through the india-rubber bag, and through the mercury in the bag and in the glass tube, compresses the fresh water in the bottle, and the mercury is forced from the bag into the bottle to fill the void caused by the compression. The quantity of the mercury forced into the bottle is a perfect measure of the extent of the compression of the water, and this compression is always exactly proportioned to the height of the compressing column—that is, of the depth of the sea. It is only necessary, therefore, to measure the mercury forced from the bag into the bottle to know with the greatest precision the depth of the sea at the lowest point of descent of the bottle. To facilitate the measuring of the mercury, Messrs. Morse, in constructing their bottle, cause a glass tube several inches long, of even bore and closed at the outer end, to be inserted in the end of the bottle opposite to the neck, so that on inverting the bottle the mercury, which at first rests in the neck on the stopper, falls into this metre tube, which is graduated, and thus shows the depth of the sea by the height of the mercury, as in the barometer and thermometer the height of the mercury indicates the weight and heat of the air.

As the bulk of all liquids is greatly affected by temperature, as well as by pressure, the indications of any bathometer based on the principle of the compression of water, in the construction of which this consideration has been overlooked, will be wholly unreliable. Messrs. Morse have guarded effectually against all error from this source, as the bottle containing the water which they compress is kept during the whole period of every sounding in a small wooden case surrounded by ice, and the temperature of its contents, therefore, is always precisely 32 deg. of Fahrenheit. It is, of course, not necessary to send down a deep-sea thermometer with their instrument.

The following are among the advantages of the Morse bathometer:

1. *The rapidity with which it does its work.*—Six hours and more, it is said, are commonly consumed in paying out and hauling in a line with a sinker attached to it in water 2,000 fathoms deep. The Morse bathometer, it is estimated, can be made to go down to this depth and return in less than thirty minutes.

2. *The certainty of its operation.*—When properly constructed, it can never fail. The various contrivances for sounding the sea by sinking weights or instruments, which are raised again with a line from the bottom, fail so frequently in very deep

water that explorers have now abandoned the trial of them there, and it seems to be generally admitted by scientific men that in the greatest depths of the ocean no reliable sounding has ever yet been made. In the Morse bathometer the weight always carries the instrument to the bottom; the detachment of the weight at the bottom is made by their device perfectly certain, and when the weight is detached the rest of the apparatus can never fail to rise to the surface.

3. *The Morse bathometer is automatic.*—The momentary attention of a single operator is all that is necessary to effect a sounding in the greatest depths of the ocean. He puts ice into the case with the bottle, marks the latitude and longitude on the tube, screws the long, straight rod into the socket at the upper end of the tube, hangs the weight on the hook at the lower end, and drops the instrument into the sea. It then takes care of itself. By its own power it moves, rapidly and uniformly, from the surface to the bottom, deposits its load there, and returning as rapidly, or (if desired) more rapidly, to the surface. The operator need not even wait to pick it up. The tube, with the bottle which it encloses and the rod which rises from it into the air, will live and ride triumphantly above the surface, amid the lashings of the waves and winds of all the storms it may encounter, and whoever picks it up at any time or at any place, however distant, may know, merely by examining the bottle, the true depth of the sea at the point marked on the tube, and may publish the information to the world. If he chooses he may then mark on the tube the time when, and the latitude and longitude of the place where, the instrument was picked up, adjust the bathometer by dropping the mercury into the bag, and re-inserting the stopper in the neck of the bottle, put ice in the case, hang a new weight on the hook of the detaching apparatus, and cast the whole apparatus again into the sea, to be again picked up by another person at another place; and thus one instrument, in process of time, may be used to make scores or hundreds of soundings, at the cost for each sounding of only the bag of sand required to sink the instrument, the few ounces of ice that surround the bottle, and the few minutes of time occupied in readjusting.

4. *The mathematical accuracy of its marks of depths.*—The Morse bathometer in its indications of depth is not affected by currents. A line, during the long time consumed in its descent, may be so swayed by currents and counter-currents that a length of twice, and more than twice, the perpendicular depth of the water may be required to reach the bottom. The meassure of the depth of the sea by a line is therefore eminently unreliable; but this instrument, constructed on the principle of the compression of water, which is always precisely as the perpendicular height of the compressing column—that is, as the depth of the sea, without regard to currents—must mark this depth with scientific precision.

5. *The cheapness of the instrument.*—A tin tube a few feet long and three or four inches in diameter; four or five hollow glass spheres of a size adapted to the tube; a small glass bottle in a wooden case; three or four ounces of mercury; a light fishing rod, ten or twelve feet long, with any glittering substance at the end that will attract attention at a distance; and a twenty-pound weight, which can be made for a dime by casting plaster of Paris into the form of a long narrow bucket, and filling the bucket with sand or stones—these are the items in the cost of an instrument with which the greatest depths of the ocean can be sounded, quickly, certainly, automatically, and with perfect scientific exactness.

Is it too much to expect that, with the facilities afforded by this instrument, we shall soon have at least one sounding on every square mile accessible by ships of the three-fourths of the surface of the earth covered by water, and that with these soundings artists will construct a perfect model of the bottom of the sea, in which all its depressions below the level of the surface will be minutely and accurately represented? How long will it be before we can have an equally accurate map-in-relief of the one-fourth of the earth's surface that rises above the water? Not until man has visited every square mile of Centra Africa, of Central Australia, and of every empire, and every island from which he is now excluded by inhospitable climates and inhospitable men.

Strange! that the bottom of the sea—the widest field of the geographer, three-fourths of his entire field, hitherto covered with a thick veil, defying all attempts to

penetrate it—should at last, by such simple means, be opened everywhere for the investigation of everybody, so that the true shape of its whole vast expanse can now be more readily, accurately, and minutely dotted down on paper, and represented in sculpture, than the true shape of any large district of the dry land inhabited by man and revealed daily in the light of the sun!

PUDDLING FURNACES.

From "The Engineer."

We are unable to say how many puddling furnaces are at work in Great Britain, for the simple reason that no statistical investigation of the question has ever been undertaken; but it is quite certain that the number must be enormous. It follows, as a consequence, that even a very small reduction in the consumption of coal by each furnace would represent a considerable saving in the cost at which English wrought-iron is produced —a reduction so great indeed, that on its existence or non-existence may in great measure depend the prosperity of the iron trade. Therefore, it is not remarkable that hundreds of patents have been taken out for improvements in the construction of puddling and reheating furnaces. It is somewhat noteworthy, however, that none of these patent furnaces are generally used, while the universal adoption of any one or two is apparently as far off as ever. The typical puddling furnace of the present day is precisely the same as the typical furnace in use twenty years ago. Some cause must account for the existence of this fact; let us see if it be possible to determine the precise nature of the cause.

Every ton of iron puddled in Great Britain may be taken to represent the combustion of 22 cwt. of coal. It is true that in some districts it is less, but in others it is more, and unless special precautions are used when certain qualities of coal are burned, it may be very much more, in some cases as much as 40 cwt. of coal being required to puddle a ton of pig-iron. We believe that most managers will agree with us when we state that 22 cwt. of coal per ton of iron puddled is rather under than over the average consumption. That this is a greater quantity than is needed either in theory or practice, is to a certain extent proved by the fact that hundreds of tons of iron have been puddled with as little as 15 cwt. or 16 cwt. of coal to the ton.; and it is quite possible that even this quantity, small as it is by comparison, is still greatly in excess of that which might be made to suffice. So far as we are aware no experiments have been undertaken to determine exactly how little coal would suffice to puddle a ton of iron. It would appear that the only work required from the fuel on the grate is done when the pig has been melted, that is to say in about thirty-five to forty minutes after the charge is introduced. The entire operation lasts about eighty minutes, when the iron is good, so that it may be safely assumed that one-half the consumption of fuel takes place after the pig is melted. Dealing first with the weight of fuel burned in melting the pig, we find that the consumption is extravagantly high, amounting as it does, from 9 to 11 cwt. per ton of pig. In a good cupola from 8 to 9 tons of pig-iron can be melted with one ton of coke when in full work. It follows, therefore, allowing about 14 cwt. of coke to be equivalent in calorific efficiency to 1 ton of coal, that 11 cwt of coal should melt about 3 tons of iron instead of 1 ton. At the most, 4 cwt. of coal should be sufficient to melt a ton of iron. When iron is melted in the puddling furnace about three times as much fuel is consumed as when iron is melted in the cupola. Of course this must be taken as a general statement strictly true under most circumstances, but more or less inaccurate as regards certain exceptional circumstances which will suggest themselves.

Apparently great economy would be secured by melting the pig in a separate cupola and running it into the puddling hearth in a fluid state. This done we save—on paper—6 cwt. of coal, or thereabouts, per ton of iron puddled. It is not remarkable, therefore, that the scheme has been tried over and over again. It has, however, been invariably abandoned,

and we cannot now call to mind the names of more than one or two British establishments where it is the practice to melt pig for puddling, in a cupola. A great objection lies in the difficulty of so arranging the cupola and the furnaces that one of the first can feed several of the latter. In point of quality, too, we understand that iron thus treated is not equal to that made in the ordinary way; but a most unaccountable fact is, that the saving of fuel effected in practice is little or nothing, because the period which elapses after the iron is introduced into the furnace, and before it comes to a boil, is nearly the same, whether it is introduced cold or melted.

One great cause of the excessive consumption of fuel in puddling furnaces lies, no doubt, in the variable temperature maintained in them. At one time we have the damper up and the furnace urged to the utmost, at another the damper is down and the heat reduced. Next we have the fire door opened while the balls are being withdrawn, during which time no fuel is placed in the grate, while large volumes of cold air rush in. Lastly, a lot of cold pig for the next charge is introduced; the temperature must fluctuate within a range of at least 1,000 deg., and those practically acquainted with furnaces will best understand how much fuel is wasted in the attempt to get a furnace which has "gone back" up to the right pitch again. It is obvious that as these changes of temperature are practically independent of the weight of iron in the furnace, economy should follow on each increase in the weight of iron dealt with; but $4\frac{1}{2}$ cwt. is about the most one man and his underhand can deal with at once. The double furnace was introduced to dispose of this objection. It is worked by 2 men from opposite sides, and the charge is about 9 cwt.; the consumption of coal is greatly reduced, but it is not found that any great advantage follows. The double furnace is exceptional, notwithstanding its economy, for reasons so well explained by Truran years ago, and so true in the present day, that we reproduce them: "It is difficult to get the puddlers to work to time. Unless this be done, no advantage is gained over the single furnace. If one be kept waiting for ever so short a period by the other, the loss in iron more than counterbalances the reduced consumption of coal. This difficulty of obtaining men who will work thus in concert, has operated against the use of double furnaces. Were it not for this circumstance they would entirely supersede the single furnace." The writer of the passage we have quoted might have added that the fault lies not so much in want of will on the part of the men, as in difference of physical capacity and skill. It is not that they won't do what is wanted, but that they can't. The double furnace, we may add, supplies an admirable illustration of the difference between sound theory and sound practice. It is a failure from causes of which the theorist would not take any cognizance whatever, and it is from, in a sense, similar causes that hundreds of patent furnaces have disappointed the hope of their inventors.

So far we have dealt with the consumption of fuel during the first stage of the puddling process only; and we have assumed it to represent about half the total consumption, because although the subsequent stages of the process occupy a much longer time, the damper is kept down from the moment the iron begins to come to nature, and the rate of combustion is accordingly reduced. It is somewhat strange, regarding the phenomena of puddling from one point of view, that any fuel whatever should be required during the latter stages of the process. The Bessemer process has taught the world that the combustion of the carbon contained in pig-iron is sufficient, not only to maintain it in a fluid state, but enormously to increase its temperature. The process of puddling, or, more strictly speaking, of boiling iron, is analogous to Bessemerizing. Why, then, should not the oxygen proceeding from the fettling, and absorbed from a flame abounding in free air, suffice to bring about a similar result? We are not aware that any completely satisfactory explanation of the fact that it does not has ever been offered. Twenty minutes suffice for the blowing of a charge in the converter. To puddle a charge occupies about twice as long, though the absolute work of giving out the carbon is effected in less time. The prolongation of the process, such as it is, will hardly account for the fact that the combustion of the carbon in the iron in a puddling furnace is not attended with the same phenomena as those present in the

converter. It may be that the presence of a large quantity of iron—4 or 5 tons—in the converter, instead of 4 cwt. or 5 cwt., as in the puddling furnace, will satisfactorily explain the fact, as it is well known that, other things being equal, the greater the quantity of fuel burning at once the higher is the temperature produced; and it is not impossible that a proportion of the economy proper to the double furnace, is due to the more favorable conditions under which the carbon is burned out of the iron. If this be so, it follows that any system of machine puddling which would permit large quantities of iron—say 3, 4, or 5 tons—to be dealt with at once, would introduce means of economy not hitherto thought of.

We have now to consider how it is that some reverberatory furnaces work with much less fuel than others. To deal with this point in full would extend the length of this article too much. We shall return to the subject; but, meanwhile, we may point out that all endeavors to reduce the consumption of fuel must be based on three general principles. In the first place, we must try to utilize the fuel within the shortest possible distance from the bridge; in the second place, we must produce the highest possible heat; and, in the third place, we must waste as little of that heat as may be. The multifarious questions connected with grates, stacks, draught, temperature of air, etc., we shall not now touch upon. For the present we wish to call attention to certain phenomena of heat which have not as yet received the notice they deserve. They bear strongly on the proposition that all the fuel should be utilized as near the bridge as possible.

It is commonly assumed that a body of gas once heated can only lose its high temperature in one of two ways. It must either impart its heat to some other and cooler body, or else do work. If it does neither, then the temperature should remain constant. The accuracy of this proposition we do not controvert. Yet we find in practice that gases apparently doing no work, and surrounded by noninducting media of the same temperature as themselves, do lose heat with startling rapidity. If we take an ordinary heating furnace, and apply it to raise steam by the waste heat, we shall quickly find that the efficiency of the coal in raising steam is very much less when so employed than it would be if burned directly under the boiler in the proper way. In a locomotive engine, for example, 20 sq. ft of grate will produce 400 indicated horse-power. In a reheating or balling furnace the temperature is certainly not less than in a locomotive engine, but the so-called waste heat from 20 sq. ft. of grate will not produce anything like half 400-horse power, assuming the engines to be equally economical, even though no iron is charged. The furnace is constructed of admirably non-conducting materials, and from the nature of the case combustion is perfect. What, then, becomes of the heat on its way from the fuel on the grate to the boiler? Furthermore, every addition to the length of the furnace neck—or in other words, to the distance intervening between it and the boiler—reduces the efficiency of the waste heat in a ratio which appears to increase as the square of the length of the neck. Why should this be? The answer is, of course, that the heat is wasted by radiation from the furnace and from the neck. To this we demur to the extent of saying that the loss by radiation is not apparently sufficient to account for the total loss. Brick is so bad a conductor of heat that the naked hand may be kept with impunity on the roof of a heating furnace 9 in. thick, inside which the temperature is over 3,000 deg. The neck is thinner, it is true; but even there the radiation must be too small to account for the actual loss of heat. It appears to us that the true solution of the difficulty must be found in the fact that work is done by the escaping products of combustion; in the first place, by expanding into a large flue after leaving the comparatively narrow throat of the furnace through which they have been squeezed, so to speak; and in the second place in friction against the sides of the flues; and in the third by internal motion. On this point, however, we shall not attempt to dogmatize; we merely wish to call attention to the fact that the temperature of the escaping gases and products of combustion decreases in a very rapid ratio with their distance from the furnace. This is not theory, but practice; and for this reason it appears that long heating furnaces are likely to be much less efficient when a very high temperature has to be maintained than furnaces of the same

capacity shorter and wider. It is possible that some of our numerous readers have experimented on the fall of temperature noticeable in non-conducting flues ; if so, they will contribute not a little to the general store of knowledge regarding furnaces by sending us particulars of their experiments for publication.

ON RECENT INVESTIGATIONS OF WEATHER.

From "The Mechanics' Magazine."

"It is a necessary consequence of the nature of physical science that, in proportion to its progress, its inquiries become more and more minute and refined. The first results in all its departments are not very distinct from common observation, and the discovery of a general fact is an important acquisition, though it may not be followed through all its modifications, nor the conditions under which it exists strictly defined. But, after a certain time, more remote objects come into view, a perfect knowledge of which can be acquired only by a very accurate examination ; and the relations of those already known being multiplied, require to be traced with more minute discrimination. The researches of science would thus always be becoming more difficult were they not aided by the acquisitions progressively made.

"From this circumstance, however, they continually require more delicate instruments and more accurate modes of experiment ; and much of the labor of philosophers is occupied in revising the more rude results of preceding periods, in ascertaining the influence of the slighter circumstances by which the objects of their inquiries are affected, and in following out those applications and those new trains of investigation which such inquiries always suggest."—"Edinburgh Review," vol. 24, p. 339.

"We are amused with the motley admixture of truth and error apparent in the works of the older authors, and the indolent acquiescence with which those errors have been copied and transmitted through succeeding ages. While we gather confidence in results which are founded on legitimate induction, we are at the same time taught a salutary scepticism with regard to those theories which rest on less direct evidence. We learn what difficulties impede us in the very outset of our inquiries; how laborious and arduous is the task of collecting accurate observations ; how liable we are to delusion from the magic power of imagination, which persuades us that we see what we expect or desire in the guise of reality, and which insensibly lures us into partial or exaggerated statements. A conjecture thrown out at random has sometimes reached the threshold of an important discovery, which has yet remained unexplored till a long time afterwards, when inquiry has led to it by a very different path. Truth often lies concealed near the very spot where we had looked for her in vain ; her subtle essence eludes our grasp in a thousand ways ; and even when fully in our view, she appears in such unexpected shapes and fantastic disguises, that we fail to recognize the object of our search."—"Edinburgh Review," vol. 25, p. 389.

If one science more than another exemplifies the validity of the philosophical generalizations on the progressive nature of science, or systematized knowledge, so ably set forth in the above quotations, it is that of meteorology. Essentially a science of observation, founded upon ocular views of phenomena, worked up by instrumental experiments, the multiplicity of laborious investigations which have been made with its accumulated data have again and again served but to show the absolute necessity of greater accuracy in instruments and processes of observing and of collating data, till its progress has at length tended to exhibit the correlation of its varied phenomena, which it has become evident we cannot hope to understand completely without the utmost refinement, both in instruments and methods of reseach. In various essays in the "Mechanics' Magazine," during the last two years, the attention of its readers has been directed to a meteorological law of the utmost importance, not only as a corroboration of the correlation of phenomena, but also as a formula of knowledge and a means of weather prevision. It is scarcely yet

generally known that there is a simple relation between the wind systems of our globe and the distribution of atmospheric pressure, that there can be no alteration whatever in the one without definite changes in the other. Nevertheless, this law is one and the same with the law of storms, which, as applied to "cyclones," has been known and demonstrated again and again during the last half century. The philosophers who established the theory of storms had dim glimpses of the universality of its fundamental law; but, wanting the means of investigation, they lacked the boldness to state it to be the law of winds. With the advance of time, observations have accumulated and improved; ideas have become conjectures; and these, submitted to the test of facts, have proved to be certainties. The stages of induction which led to the complete cognizance of this general law are full of interest, and afford a lesson in the philosophical progress of meteorology which cannot but prove instructive, and is certainly a hopeful promise of the further development of the science.

This law is at present usually associated with the names of Buys Ballot, the meteorologist of Utrecht, but it appears to us that it might, with more justice, be named after W. C. Redfield, the eminent meteorologist of New York. He appears to have been the first to assert the universality of the law of storms as applicable to all winds. The "Nautical Magazine," in 1836, published Redfield's theory of hurricanes, and his beautiful discovery that, in both the northern and the southern hemispheres, the hurricane wind, which is next to the equator, always blows from west. His theory and discovery have been amply verified in all latitudes, and they enable navigators to know the direction in which the focus of a tempest lies from a ship, and by inference, from the known usual paths which storms follow, how to avoid it. In the same magazine for January, 1839, Redfield wrote:—"To me it appears that the courses of the great storms may be considered as indicating, with entire certainty, the great law of circulation in our atmosphere; and that the long-cherished theory, which is founded upon calorific rarefaction, must give place to a more natural system of winds and storms, founded mainly upon the more simple conditions of the great law of gravitation." Writing in the same periodical so late as 1854, he further states: "As early as 1833, my inquiries led me to announce the conclusion that the ordinary routine of the winds and weather in these latitudes often corresponds to the phases which are exhibited in the revolving storms already described, and that a correct opinion, founded upon this resemblance, can often be formed of the approaching changes; and that the variations of the barometer resulting from the mechanical action of circuitous winds, and the larger atmospheric eddies, pertain not only to the storms, but to a large portion of the winds in these and the higher latitudes" (*vide* "American Journal of Science," 1833, vol. xxv., pages 120 and 129).

"At the late meeting of the American Association for the Advancement of Science, held at Cleveland, an ably elaborated paper was presented by Professor James H. Coffin, of Easton, Pa., on the relations which exist between the direction of the wind and the rise and fall of the barometer.* By a careful analysis of these effects during all seasons of the year, Professor Coffin establishes the north-eastwardly progression and left-wise rotation of a continued series of cyclones, in which are developed the same local relations between the rotary action of the various winds and the movements of the barometer that are found in the several rotary storms and hurricanes which have been subject to investigation. Thus, if I rightly appreciate the labors of Professor Coffin, the cyclonic character of the variable winds in the temperate latitudes, which had been inferred from special observations, and an extended range of geographical inquiry, is now established by a different and wholly independent method of investigation.

"The storm paths and routes of the cyclones clearly indicate also the true course of the principal circulation in the lower atmosphere on both sides of the equator. An enlarged view of these physical truths and conditions may serve to convince meteorologists and others of the necessity for a thorough revision and correction of the received views of dynamical meteorology. Such revision, I apprehend, is now imperatively required."

These quotations are so conclusive as

to the conviction in Redfield's mind upon the subject that there can be no doubt that the universality of the law of winds would have been established by him had there been available in his time the accurate simultaneous observations needed for the proof. These came with the meteorological telegraphy devised by Fitzroy, Le Verrier, and Ballot. Fitzroy based his weathercasts mainly on the theory of storms; therefore it is to be inferred he considered it applicable generally to the winds of Western Europe at least, but tacitly, for he nowhere maintains it to be the law of the winds.

In 1863, Francis Galton, F. R. S., published "Meteorographica," and, so far as we can find, it contains the first distinct statement and proof that the winds of Europe are controlled by the law. Says the author: "When lists of observations are printed in line and column, they are in too crude a state for employment in weather investigations; after their contents have been sorted into charts, it becomes possible to comprehend them; but it requires meteorographic maps to make their meaning apparent at a glance." The work explains a method of charting observations and also of representing pictorially the phenomena which they express, everything being fully illustrated by weather charts and maps for December, 1861, for the area comprised between the meridians of 10 deg. W. and 20 deg. E., and the parallels of 62 deg. and 42 deg. N., which is about 1,200 geographical miles in latitude, and about the same in longitude, including the British Isles and the whole of Western Europe. These maps testify that frequent wind currents sweep with an unbroken flow over the area; that the Alps form a barrier which the winds seldom overleap without change of direction, and that the mountains of Eastern Germany usually divert them; that the areas of barometric elevation and depression are enormous, and in their main features very regular, but they are ever changing their contours and their sections, whilst they also vary in the speed and direction of their movement of translation; that the areas of calms are invariably the centres of whirls of wind, or are situated between conflicting currents; and that there is one marked condition of temperature and cloud in connection with the wind, which is persistent, beautifully marked, and full of interest, namely, that a westerly wind is accompanied by an overcast sky and a warm temperature, while with an easterly wind the sky is pure and the cold intense. Further, they testify to the existence, not only of cyclones, but of what the author terms anticyclones. To quote *verbatim*, one universal fact is "that on a line being drawn from the *locus* of highest to the *locus* of lowest barometer, it will invariably be cut more or less at right angles by the wind; and, especially, that the wind will be found to strike the left side of the line, as drawn from the *locus* of highest barometer. In short, as by the ordinary well-known theory, the wind (in our hemisphere) when indraughted to an area of light ascending currents, whirls round in a contrary direction to the movements of the hand of a watch; so, conversely, when the wind disperses itself from a central area of dense descending currents, or of heaped-up atmosphere, it whirls round in the same direction as the hand of a watch." No allusion, whatever, is made to the enunciation of this general law, which Buys Ballot claims to have made previously. It was possibly arrived at independently, the one not knowing what the other had done; but, whether it was so or no, Galton was evidently the first to work it out by a correct method. Ballot used par valves of atmospheric pressure in his method, as will be seen farther on, and had his stations been more extended, the law would have been masked or misinterpreted. Galton used barometric readings simply reduced to the sea level, which subsequent experience has confirmed to be right.

In the same year, 1863, a pamphlet was published in London, entitled, "The Foretelling of the Weather in Connection with Meteorological Observations," by F. H. Klein, translated from the original Dutch by A. Adriani, M. D., etc. Klein was assisted in the compilation of his pamphlet with the advice and information of Dr. Buys Ballot, Director of the Meteorological Institute of the Netherlands. Nevertheless, read in the light of our present knowledge, the greater part of it is of no value, but it contains the following important statement, said to have been verified by Buys Ballot:—"It is one of the general rules concerning the force and direction of the wind that the wind will

always be in an easterly direction when localities situated to the northward of some place of observation have a high reading of the barometer; and, on the contrary, the wind will be in a westerly direction when the reading of the barometer is higher in localities situated to the southward of the same place of observation. In the first instance, the wind, without exception, is between south-east and east-north-east, whereas the westerly direction is again almost without exception between south-west and north-west. If it so happens that at the same time there is a difference of the reading of the barometer between localities situated in an easterly and westerly direction from each other, the wind in the first case will partake more of the northerly, in the other case more of the southerly direction. The future direction of the wind, therefore, may be determined by the following rule. When one has the lowest reading of the barometer to one's left hand, the back is turned to the region whence the wind will blow." It is certainly wrong to assert that the rule as thus stated determines the future wind; what it determines is the present wind merely. There can be no doubt, however, but that the law as explained by Klein is the basis of weather forecasts; only a rate of rise or fall of the barometer must be assumed, or limiting angles for oscillation and veering of wind must be assigned. We shall see, hereafter, that Mr. Strachan expounds the principles of forecast on the former assumption, and Mr. Scott on the latter. Dr. Ballot discovered the law by means of observations from four stations in Holland in telegraphic communication with Utrecht. He calculated the barometrical differences from the daily observed and the normal values of atmospheric pressure at the stations, and he went through the great labor of deducing the normal values from long series of observations made at each place, before he could put his theory to the test. It was favorable to the result that, Holland being a small country, the stations were not far apart. There being little difference of latitude between the stations, the normals were all much alike in amount, and their difference only slightly affected the investigation, but still it gave rise to erroneous notions. Thus Klein states that an ordinary difference (barometrical) north above south is less to be apprehended than an equally large difference of south above north. He was very desirous that Admiral Fitzroy should adopt the method of dealing with normal barometric values as practised in Holland. "By assiduous and carefully conducted barometrical observations, one has succeeded in constructing normal tables which exhibit for every day of the year the average reading of the barometer for the place of observation. Suppose the average or normal reading for a certain day to be 761 mm., while the barometer on that very day reads 770 or 752 mm., then, in the first instance, the reading, as compared with the average, is 9 mm. too high, in the other, 9 mm. too low; in other words, the departure from the normal is + 9, or − 9 mm. The knowledge of the origin and meaning of such departures is, therefore, highly important; it is just herein that the main difference between the system of observations adopted in Great Britain and that just alluded to and followed in Holland, exists. According to the British system, attention is chiefly paid to readings which only indicate a certain height and movement of the barometer. I think the system now generally adopted in Holland since 1860 would benefit Great Britain and Ireland." There is no necessity whatever to take any trouble about the normal values of atmospheric pressure, since the direction and force of wind are related to the existing distribution of pressure, as shown by barometers. Thus it happened that the limited extent of Buys Ballot's stations enabled him to establish on an imperfect induction the generality of an important meteorological law.

A pamphlet entitled "Principles of Weather Forecasts," by R. Strachan, published in 1867, clearly generalizes the subject, and is the nearest approach to a mathematical exposition of the law and of the principles involved in weathercasts that has yet been attempted. He explains the problem of forecasting weather by the method of co-ordinates; and shows that our foreknowledge of wind and weather would be certain did we know the rate of increment or decrement of barometric pressure that would occur in a given time; and shows the probabilities of the problem. "In 1865, according to the Greenwich observations, 74 per cent. of the

transitions of atmospheric pressure from maximum to minimum, or *vice versa*, lasted longer than 24 hours; and, on an average, the duration of each rise and of each fall of the barometer was 2 days; 4 transitions lasted respectively, 6, 7, 8, and 11 days." "If the law of barometric variations were known, or if any law of periodicity, as regards barometric maxima and minima, could be established, then the forecasting of weather could be reduced to a very accurate system; it would be a simple mechanical problem, and mathematicians would soon reduce it to accurate formulæ."

We have next to mention "An Inquiry into the Connection between Strong Winds and Barometrical Differences," by R. H. Scott, M.A., officially published by the Meteorological Committee under the incongruous denomination of "Non-Official Report, No. 1." It has been to us, we must confess, a work of no small labor to get a good idea of the plan and purport of this elaborate statistical inquiry. We despair of rendering the arrangements, conditions, and tabulations intelligible to our readers. Really and truly it is an inquiry into the possibility of forecasting the coming winds, and, as a corollary, the weather. The method of testing propounded is virtually a method of forecasting, and we shall best judge of it by the results to which it leads.

The investigation fully confirms the law about which we are writing, and which Mr. Scott, on the authority of Buys Ballot, says may be stated in these words:—"If any morning there be a difference between the barometrical readings at any two stations, such as Groningen and Maestricht, a wind will blow on that day in the neighborhood of the line joining those stations, which will be inclined to that line at an angle of 90 deg. or thereabouts, and will have the station where the reading is lowest on its left-hand side." It is to be noted, however, that this is an elastic expression of the law. The correct way of stating it is that the wind current flows nearly parallel with the isobaric curves, or curves of equal pressures, having the lowest pressure on the left of its course, the highest on its right, and that its velocity is related to the inequality of pressure or the distance apart of the isobaric curves.

The first inquiry is, "What is the connection between general barometrical disturbance and weather succeeding it?" The result obtained is: That if we notice on any morning a difference of 0.6 in. of barometric pressure between any 2 stations of the British system of telegraphic meteorology, the chances are 7 to 3 that there will be a storm within the succeeding 24 hours; and the chances are 9 to 1 that any storm which sets in will be preceded by unmistakable signs of its approach, although the barometrical difference of readings may not amount to 0.6 in. at the time. This is highly satisfactory evidence of the signs afforded for storm prevision.

The other portions of the investigation are for the purpose of testing the law as applied to the different districts of the British Isles and the north and west coasts of France. Here Mr. Scott finds it necessary to assign limits for translation of air and veering of wind altogether incompatible with the statement of the law previously given. He says:—"Firstly, the whole system of isobaric curves, or the whole distribution of atmospherical pressure, is known to be subject to a motion of translation over the earth's surface, but of this motion the direction and the rate vary, from day to day, to a considerable extent, and in a manner independent of each other. Neither of these points has been as yet satisfactorily investigated.

"Secondly, the wind, especially in storms, seldom blows for many hours consecutively from the same point, but either veers or backs, the former motion being much more usual than the latter.

"These considerations show us that we must not interpret the law too strictly, but must make some allowance for translation and for change of direction. For the former, about 100 miles in any direction has been allowed; *e. g.*, a westerly gale at Weymouth is considered to be amply foretold by an indication for a strong west-south-west wind between Brest and Penzance. For the latter an angle of 45 deg. for veering has been allowed, but no allowance has been made for backing."

The inquiry now is, "What accordance do the strong winds actually observed show with the directions over each district of the area as given by the law?" The

winds observed were experienced within 24 hours succeeding the indication. Besides the allowance of 45 deg. for veering, a limiting angle of 45 deg. is assigned on each side of the indicated direction, making an arc of 135 deg. in favor of the indication, and of 225 deg. against it. "As regards direction, the inquiry affords a very strong confirmation of the law, as 94 per cent. of the barometric gradients recorded were succeeded by winds in the direction indicated by the law. As regards force as well as direction, the result is also in accordance with the principle laid down, especially as regards south and south-west winds, but the mean percentage of agreement is only 61."

Finally, inquiry is made as to "what amount of indication was given by each strong wind by barometrical differences in its vicinity?" But, as this is an inversion of the process involved in the previous inquiry, its conclusions, of course, ought to be, as they are, similar.

It should be mentioned that the winds under consideration are those recorded of force 8 or upwards of the Beaufort scale. The barometrical difference assumed as a sufficient indication of such a wind is 0.12 in. per 100 miles.

Mr. Strachan assumes 7 times the barometric difference (d) between places about 500 miles apart as the mean force (f) of the existent wind ($7 \times d = f$). Hence, if $f = 8$, $d = 1.14$ in. for 500 miles, or 0.23 per 100 miles, which is nearly double that assumed by Mr. Scott. It is therefore apparent that the relation of barometrical differences to wind force have yet to be investigated; and it will be found, we are quite sure, a subject of great importance. We incline to the opinion that the factor will be different for the same grade of force for wind from the different quarters.

This thorough investigation of this important law of wind may be said to have completely verified it; and Mr. C. Meldrum, of Mauritius, has since confirmed its validity for the winds of the southern hemisphere. Thus, common observation having at first given indications of it, more accurate examination with suitable data, has established it as a truth.

THE "FLUIDITY" OF SOLIDS.

From "Engineering."

There have probably been no investigations carried out during the past few years which possess a higher scientific interest than the admirable series of experiments which have been conducted by M. Tresca, on what he has aptly termed the "flow of solids." The subject is one which has been frequently noticed in our pages, and in our number for June 7, 1867, we published the valuable paper by M. Tresca, read before the Institution of Mechanical Engineers, during their meeting at Paris that year. This paper, with which many of our readers are no doubt familiar, contained a full account of the results which M. Tresca had obtained up to that date, and of the deductions which were to be drawn from them; but since then M. Tresca has devoted further attention to the subject, and it is of the results of his more recent investigations that we now desire to speak.

M. Tresca's earlier experiments had shown that when a solid body, such as a metal, was subjected to the action of a compressing force more than sufficient to overcome its elasticity it behaved more or less like a fluid, an actual "flow" of the particles taking place. The pressure necessary to produce this flow has been named by M. Tresca the "pressure of fluidity," and one of the objects of his later researches has been to determine this pressure in certain cases. Moreover, it is clear that when a solid is subjected to pressure, the action of that pressure is most intense at the point where it is directly applied, and becomes less and less intense as that point is receded from; and hence it may be assumed that there is, in fact, a limit beyond which, practically, no action whatever takes place. The area comprised within the limit just mentioned has been named by M. Tresca the "zone of activity," and another object of his more recent investigations has been to ascertain the limit of this zone in certain instances.

It necessarily follows from the assumption that the "zone of activity" has, practically, definite limits; that the resist-

ance which any given punch will experience in being forced through a given metal is also limited, and that there is, in fact, a certain maximum beyond which the resistance cannot rise, however great the thickness of the metal to be traversed may be. Let us suppose, for instance, a punch to rest upon a plate having a thickness which is very considerable in proportion to the area of the punch, and let us suppose the pressure on the latter to be gradually and steadily increased. Under these circumstances a "zone of activity" of gradually increasing size will be formed beneath the punch, this increase going on until the intensity of pressure on the latter is equal to the "pressure of fluidity" of the particular solid which is being experimented upon. As soon as this point is reached the resistance to the motion of the punch will, according to the theory we are now enunciating, cease to increase, and the latter will descend steadily, the metal flowing laterally from beneath it. This, of course, will only continue to be the case so long as the "zone of activity" is contained wholly within the thickness of the plate. As soon as the punch has descended so far that the "zone of activity" touches the under surface of the plate, the latter commences to bulge, and, there being a free outlet below, the lateral flow of the metal ceases, and the shearing action commences.

That the action above described does really take place under the circumstances we have supposed, has been proved by M. Tresca's later experiments, and we cannot but regard the fact as one of very high scientific interest. We hope in a future number to give a detailed account of M. Tresca s more recent researches, and of the deductions he has drawn from them; for the present, however, we must merely remark that the values of the "pressure of fluidity" of any material, furnished by various experiments, have been found to remain sensibly constant, and that they approximate closely to the number representing the resistance to shearing.

CLARKE'S QUINCY RAILWAY BRIDGE.*

This valuable work deserves a cordial greeting from the engineering profession, not only by reason of its intrinsic merits as a book of reference, but as marking the introduction into America of the excellent practice in vogue among European engineers, of publishing carefully prepared memoirs of their more important works. Although the engineer may congratulate himself on being free from that servile rule of precedent which is the bane of the legal profession, he cannot afford to be ignorant of the achievements of others, and though much of his most difficult work may lie in the province of invention, this invention will generally be more in the direction of improvements or former plans than in the adoption of essentially new ones. The increasing circulation of professional periodicals is the best evidence of the value which is now set on records of engineering precedents, but the descriptions for which room is found among the closely printed pages of a magazine are fragmentary and imperfect when compared with the fully illustrated volumes which are specially devoted to single important works. Such volumes have a value extending beyond their descriptive character; they are commentaries on previous constructions of similar character to the one illustrated; in them former plans are reviewed, indirectly, it is true, from no imperfect theoretical basis, but by the hard rule of tried experience, all innovations on established customs being tested by actual success or failure. Few volumes contain more valuable information on the construction of metallic arches, than the descriptive memoir of the Coblentz bridge across the Rhine; while probably the one work which gives the most complete idea of the merits and difficulties of pneumatic foundations is Vuigree & Fleur St. Denis's "Pont sur la Rhin a Kehl."

The volume before us is a work of very similar character to the two just mentioned; it is descriptive of the largest and most important of the five great railroad bridges which now span the Mississippi,

* An account of the Iron Railway Bridge across the Mississippi river, at Quincy, Illinois. By Thomas Curtis Clarke, C. E., Engineer-in-Chief. New York: D. Van Nostrand, 1869.

and which was, until the very recent completion of the bridge over the Ohio, at Louisville, the longest iron bridge in the United States; the length of the bridge across the main channel alone, being no less than 3,250 ft., while over 600 additional feet of iron bridge are included in the approaches. The iron superstructure rests on masonry piers, which are built on pile foundations. The character of the work, with the exception of the pivot pier, of which more will be said hereafter, was therefore of no unusual kind; but the adaptation of these simple and well-tried methods of founding to a work of such magnitude, involved many points of interest and originality, especially as it was wished to complete the bridge at the earliest possible moment, and the works had to be arranged in such a manner as to be practically independent of the varying stages of water in the river.

Perhaps this very fact, that the foundations were of a character which every engineer must expect often to make use of, really adds to the value of the book.

Treatises on extraordinary works, in which few men are ever so fortunate as to be concerned, like "Brunel's Subterranean Masterpiece," or, "Stephenson's Great Tubular Bridges," often present themselves with exasperating readiness, to those who are trying to find a good set of working plans for a common pile-driver, or to devise some economical means of starting a foundation a few feet under water. The work before us will supply many deficiencies of this kind; its 20 plates are full of matter which may come into use upon a bridge over any ordinary stream. The extensive false-works which united the long line of piers, so that the machinery in use at one point could be transferred in a very few minutes to a remote foundation, involved a greater amount of preparation than it would ordinarily be wished to make; but the machine used for cutting off the piles, the arrangement of the suspension screws by which the masonry was lowered upon its foundation, the method adopted to bind the piles together and to protect them from scour, have nothing in their character which prevents their general adoption on works of very different magnitude from the one in question.

The book is somewhat obscure in regard to dates, but from official sources we have learned that the surveys were commenced November 21, 1866; delivery of materials began January 15, 1867; first foundation put in, September 15, 1867 first iron span raised, December 28, 1867 last pier completed, August 5, 1868; bridge opened for traffic, November 10, 1868; so that the whole time occupied, including surveys, was less than 2 years, of which 22 months was employed in preparing materials, construction, and about 14 months in actual construction after the state of the river admitted of putting in foundations.

The bridge as designed and built consists of a pivot draw 362 ft. long over all and 16 fixed spans, of which two are 250 ft. long, three 200 ft., and the remaining eleven 157 ft. each. To this must be added the bridge over the Quincy Bay, consisting of a pivot draw 190 ft. long and 4 fixed spans, each 85 feet long. The volume contains a careful review of the regimen of the Mississippi, which is illustrated by application of hydraulic formulæ and accompanied by a careful computation of the discharge area of the river at the bridge line. It is to be noted, however, that the mathematical calculations, which have been carried out with no ordinary care, are modestly placed in an appendix, where they form no interruption to the smooth reading of the text. The accuracy of their computation is forcibly illustrated in the case of Messrs. Humphreys & Abbot's velocity formula, which gave results differing from those obtained by actual measurement by less than one per cent.

In determining the method of construction of this bridge the first point aimed at, was to be independent of the varying stages of the water, so that no interruption might occur between the inception and completion of the work. This was accomplished by the use of the extensive false-works already referred to. These false-works rested on piles and extended entirely across the river, with the exception of the draw openings; a railway track was placed on each side of these works on which service-cars were run back and forth, while outer rails were also laid down, on which ran the travelling cranes used in laying the masonry and transferring the machinery from pier to pier. This immunity from high and low water

secured, the next principle followed in the preparation of the plans was the dispensing with all pumping and coffer-dam work, the doing everything above the water level which could possibly be done at that elevation, and the employment of divers to do such subaqueous work as might be absolutely necessary. The excavation was made by an endless chain dredge, the piles were cut off by a circular saw, and the masonry was laid above water and lowered by suspension screws, or, in the case of two of the piers, in floating caissons, till it rested upon the prepared pile foundations ; the spaces between the pile heads was carefully filled with hydraulic concrete, the manipulation of which formed one of the chief tasks for the divers. The wisdom of this selection of plans was shown by the rapidity with which they enabled the work to be carried forward. The transfer of the heaviest machinery, the pile-driver or dredge, from one foundation to another, was the work of but a few hours ; delays from leaks and overflows were impossible, and when the masonry had been completed the false-works were ready for erecting the superstructure.

The sole exceptions to the general plan of works were the two abutments and the two west piers. The two former were founded on beton, and the two piers mentioned were separated from the remainder of the bridge by the draw openings. One of them was founded on piles in a manner but slightly different from that pursued on the other foundations nearest the channel ; the other, the pivot pier, was founded on four wrought-iron columns, 14 ft. in diameter, which were sunk, by dredging within them, to the bed of gravel which overlies the rock, 38 ft. below water, and filled with beton ; the pier was then built in a floating caisson and sunk upon its foundation by the weight of the masonry. The building of this pier occupied about a year, and seems to have been the only part of the work on which the original expectation of the engineers were not fully realized ; it is but justice to the engineer and author to say that he frankly admits, that in constructing another similar work he should wish to modify materially this part of his plan.

The stone used in the masonry was mostly brought up the river from the well-known stone quarries at Grafton, Illinois; a portion, however, was quarried at Hamilton, opposite Keokuk. The same completeness which characterized the outfit used in constructing the piers and foundations, was extended to the machinery used for unloading the stones. As fast as delivered they were piled up in positions where they should be accessible at all stages of water, and arranged in the order which would involve the least handling when the time came for placing them in the work. The form of pier adopted, while involving no marked departure from the forms in most common use, is exceedingly well proportioned and neatly trimmed, reflecting no small credit on the artistic taste of the designer.

The superstructure is entirely of wrought-iron, with the exception of the upper chord of the fixed spans, which is of cast-iron. The use of cast-iron we consider an error, for which, however, the engineer was not responsible. It was built by the Detroit Bridge and Iron Works. The plan of the main bridge is a Pratt truss in which the diagonal ties extend over two panels, while the end panels are made of double length by the use of leaning end posts, the floor being suspended from the centre of this panel by vertical rods. The depth of truss is made to vary with the length of the spans, being always twice the length of a panel, or $\frac{2}{19}$ of the full length of the 250 ft. spans, and $\frac{1}{7}$ of the length of the 157 ft. spans. The draw is fitted with a steam-engine placed in the centre above the track, by which it is turned and by which the deflection at the ends is taken out when the draw has been closed. The superstructure of the bay bridge is a Bollman deck bridge, the draw being of similar pattern, and hung over a central tower by log chains. In this bridge the vertical posts as well as the boom are of cast-iron, except that of draw, which is of wrought-iron. The abutments of the bay bridge are of the T form with an arch thrown in the T, an arrangement adapted to facilitate the construction of the foundations, but no less successful in its architectural effect. The calculations of the strains on the different members of the trusses are given in full in the appendices, and the details of construction are illustrated on the plates. In the same connection are given a number of tables of experiments on the strength of iron, which, embodying the

results of actual experiments made on material manufactured for this particular work, are a real addition to the amount of knowledge already possessed on this interesting subject. The tables illustrating the comparative strength of tension bars enlarged at the end, in two different ways, by the insertion of a wedge and by upsetting, are specially instructive. Another table of no small value is that given in Appendix No. 4, in which the weights of several varieties of iron bridges are compared; the principal portion of this table is compiled from the designs which were submitted by the contractors who made bids for the superstructure of the Quincy Railroad Bridge, but the table also embraces a number of the more noted bridges which have been constructed abroad.

Appendix No. 3, which contains the specifications of stone, timber, and iron work, is very valuable for reference, and contains much matter in a small compass. The use of beton for the backing of ashlar work, which was adopted almost universally on the Quincy bridge, is a practice somewhat novel in America, but one which deserves a thorough examination; whenever used it has been favorably reported upon, and with the improvements which have recently been introduced abroad in the manufacture of beton, it is undoubtedly capable of a wide extension in use.

The last chapter of the volume is a succinct statement of the cost of the work. Like all collections of figures, it is dry to the general reader; but as it embraces many matters of detail, it can be easily made of service in preparing estimates of similar works, and is by no means the least valuable part of the book.

There are, it must be admitted, some few parts of this book which are not above criticism. In the tables giving the strains in the superstructure, the draw when closed is treated as if formed of two disconnected girders of 180 ft. each, a supposition which must evidently give results materially different from the strains which actually occur under these circumstances. It is true that when the deflections have been taken out at the ends by the lifting gear provided for that purpose, the actual strains are so much reduced as to fall within the limits given in the tables of maximum strain (excepting in the central panel ties and posts); but this will hardly justify the computation of strains upon a mistaken hypothesis, still less the publication of such computations. Again, in the case of the fixed spans, the counter-ties are credited with a strain from the centre to the end of the truss; whereas it is well known that only 2 or 3 of the counters on each side of the centre will ever be subject to any strain. Curiosity also raises the question of how the strains on the panel ties of the Bollman truss, which are carefully figured out in pounds, are computed. Though these are undoubtedly errors, they are errors which are not peculiar to this book, and which are really to be ascribed to the superficial method in which these matters have generally been treated by bridge builders, rather than to the fault of the author, who has generally shown an excess of care in his calculations.

It is to be regretted that the style in which the book is published is not worthy of the matter which it contains. This is especially true of the plates, which are comparatively coarse photo-lithographs, and, like some of the ancient philosophers, mask their real merit by a coarse exterior. The Quincy Railroad Bridge is a carefully finished structure, and with all its magnitude presents a graceful and attractive appearance; this volume descriptive of it has been carefully prepared and needs only a corresponding exterior beauty to be a fitting counterpart to the actual work.

CHANNEL FERRY.—Mr. J. S. Mackie thinks he has solved the problem of a rapid and easy ferry from Dover to Calais, by his swift Channel passenger steam-vessel, which will carry a thousand passengers at once, and roll not more than 13 in. in the stormiest sea. He showed at the Royal Society's *conversazione* on the 5th instant, two models, one of which, eight feet in length, steamed merrily up and down a tank provided for the occasion. Two waterways, with three paddle-wheels working in each, extend from bow to stern; and it is asserted that the vessel, when built, will cross the Channel in less than an hour.

EAST RIVER BRIDGE.—Borings on the site of the west pier were commenced on the 15th of May.

INFLUENCE OF THE SUEZ CANAL ON TRADE WITH INDIA.*

It seems to me that the subject may be conveniently viewed under two heads, the one showing how, by means of the canal, India is brought closer to Europe for purposes of commerce, and how new fields of commercial enterprise may be opened up, which hitherto have been inaccessible except at great cost and lengthened periods of transit, economizing in the same process that most valuable of all commodities, time; and, under the second head, it may be shown that increased communication and rapidity of transit will make and supply increasing wants, and in so doing, develop the resources of India, and distribute them for the benefit of the world at large.

I propose to confine my own remarks to the first of these two branches of the subject, leaving other gentlemen, better qualified than myself, to deal with the second.

It will be necessary, in the first place, to see what distances at the present time have to be traversed between ports of British India and ports of Europe, *via* the Cape of Good Hope, and then to compare them with those between the same ports *via* the Suez Canal, ascertaining at the same time how, if enhanced freights are required for steamers by the latter route, they will contrast with the loss of time by sailing vessels on the former.

Assuming, then, as a fact, that the Suez Canal is so far successful that there are now no obstacles to its being freely traversed by steamships, as ordinarily used for commercial purposes—a fact which, if a matter of doubt at its first opening, is now unquestionable from the use that has already been made of it, and the removal of the only serious difficulties to its navigation—one or two general propositions may be laid down for convenience in argument, and for the purpose of saving further reference, viz.:—That steamers may be considered to average a rate of eight to nine knots per hour, and sailing ships five to six knots per hour, and that uncertainty as to time of delivery can be brought to a certainty by steamers only. In speaking of sailing vessels, I assume that they will practically be the only carriers on the Cape route, and have purposely excluded steamers from consideration as regards that line of traffic, because at the present time it is well known that the expense of the fuel for the long voyage is so great, and the time saved so trifling in comparison, that steamers are not an ordinary means of transit. As science advances in the economizing of fuel, there may be an improvement in this direction, but it will require vessels of great power and speed to shorten the mileage now entailed by the prevalent winds within the tropical belt. With these general propositions and my own experience to guide me, I have drawn out a table which shows, with sufficient accuracy for the present purpose, the comparative mileage transit between port and port actually traversed, and the time occupied in making the passage. They are, taking the Land's End of Cornwall as a common point of departure from England, or ports in Europe north of Brest, as follows:

Port.	*Via* the Cape.	*Via* the Suez Canal.	Difference.
	Miles.	Miles.	Miles.
Bombay	11,500	6,300	5,200
Kurrachee	11,200	6,100	5,100
Calcutta	13,000	8,000	5,000
Singapore	13,000	8,200	4,800

In point of fact, therefore, to a steamer averaging 8 knots, and to a sailing vessel averaging $5\frac{1}{2}$, which, considering the area they have to traverse at times to make their course and distance good, is the outside that can be allowed to them in the most favorable seasons, the time occupied will be as follows, omitting fractions of days:

* From a paper by Sir Frederick Arrow, published in the "Artizan."

Port.	Steamer in days.	Sailing Ship in days.	Difference in favor of Steamer.
Bombay............	33 + 3 coaling = 36	87	51
Kurrachee..........	32 + 3 " = 35	85	50
Calcutta............	42 + 5 " = 47	99	52
Singapore...........	43 + 5 " = 48	51	51

Having thus disposed of the question of mileage and time, it remains to be seen whether these advantages compensate for the increased cost of navigating a steamer. This is not very easy to arrive at, for there are at present so many varieties of engines and such differences in the cost of the motive power, the principal element, that any sort of average would be fallacious. I propose, however, instead, to take as an example, a class of vessel now being built, combining carrying capacity and economy of fuel and wages, which will, I think, be a type for this trade, and to compare it with an average sailing vessel of the class mostly used in the trade, founded upon the experience of actual voyages made, the two vessels being of about equal carrying capacity, say about 1,200 tons burthen each. I find that, as regards times of transit of the latter, they nearly coincide with the calculations I have above made, but independently of them. The steamship will carry, in addition to her stores and coal for 28 days, 900 tons of goods; the sailing vessel, 1,200 tons.

The portage bills for both vessels are nearly the same; the canal rate on the steamer is about 6s. per ton on 900 tons of freight—say £270. The cost of coal may be averaged at 35s. at all ports, and the amount consumed on a passage to Calcutta would be a little over 400 tons. Taking, therefore, as an example, the voyage in which the sailing vessel would do best, viz., from Calcutta to London, the following would be an approximation to the result:—The steamer would do the distance in 47 days, her expenses being—coal, £700; wages, £300; canal dues, £270; total, £1,270; and she would deliver 900 tons of goods, say at £3, £2,700; leaving net earnings, £1,430. The sailing ship would deliver 1,200 tons in 99 days; the wages, steam hire, etc., would come to at least £700, and crediting her with the same rate of freight, would net £2,900, or as near as possible double that of the steamer, and occupying more than double the time. As the steamer, therefore, will make two voyages to the sailing ship's one, it seems to me the case is made out that the canal can compete successfully with the Cape route. I have not attempted to go into minute calculations as to insurance, repairs to vessels, original cost, etc., but I think I have gone far enough to prove that steam can compete, *via* the canal, with sailing vessels by the Cape. I have purposely put the case favorably to the latter. I have taken the freight at equal rates. I have not touched on a round voyage, when not only would the outward freights be more against the sailing ships, and the cost of coal more in favor of the steamers, but the loss of time would be still greater, and I have taken the port of Calcutta as furthest to the eastward, and therefore more favorable to the sailing vessel. On the west side of India, the results would be proportionately more in favor of the steamer, as I have stated in a little pamphlet, lately published, a copy of which I had the honor to send to this Society.

Assuming it as proved that the Suez Canal can compete with the Cape route, let us see what further advantages it presents. I think we may say it will probably open a considerable trade between India and Italy, the Morea, Islands of the Grecian Archipelago, and the countries bordering the Mediterranean, including Spain, whose industry, although still undeveloped, is represented by many cotton and other factories at Barcelona and elsewhere on its Mediterranean shore. It will probably create a direct trade between the coasts of the Black Sea and India, by placing the latter in direct communication with Russia and her teeming population. By the Cape route all these places are excluded from direct communication, except perhaps those immediately contiguous to the Straits of Gibraltar, and we may consider Marseilles as the point at which supply comes no longer from the westward.

On a previous occasion, a remark was made that there was not much credit due in making this canal. It was said that it was simply supplying a want for which the time had come. It struck me then that no greater compliment could be paid to the eminent man by whose perseverance and energy the undertaking has been carried out, and I accept it as conveying what, in my opinion, is the highest praise that can be bestowed on it. I believe it is a real want, and that its supply is another link in the chain which binds mankind together, and in which each successive link of discovery of nature or science is forged with stronger power. It is within my memory, as of many here, when the first steamboats were put on the waters, when the iron horse first traversed the rail; and we have all seen how the necessities of those great advances in communication required still further development. Thought was required to travel faster than locomotion by the very advantages the latter gave, and then came that wonderful discovery of the electric telegraph, now being carried to such perfection that, ere another two years have passed away, we may feel the furthest ends of the world to be as practically familiar to us as are now Paris or Vienna; but this again creates fresh wants, requires greater rapidity, regularity, etc., and in obedience to this law, the Suez Canal has been formed.

I will not pursue the theme—it is as diversified as it seems to be endless; but I claim for the Suez Canal and the enterprise of its great and large-minded author a fair and full recognition. At the present moment its influence is being felt in a decrease of the cost of fuel east of the Isthmus, which certainly will have great effect on the cost of carriage, and therefore in the cost of laying down produce and goods. The existence of this route, it appears to me, will stimulate production, not only in India, but in the various countries which it brings into the family of commercial relations, and seems to me the natural channel for the produce of India. If so, it must increase that produce, and must benefit India itself. England wants cotton, so do other countries—a want likely to increase—and at the moment that a network of railways has connected the great port of Western India with the cotton districts, comes into being that channel which will most quickly and cheaply take the staple to the place where it is needed. From the northwest by the Indus and the railway system of the Punjaub, another great feeder to it opens, while the rail from Madras to Baypore on the west coast gives a speedier and cheaper transit from the east coast of India, *via* the Canal, than by the Cape. These are considerations, however, which come more under the second head of this subject, and I do not propose to enlarge upon them, as they will be, I am sure, done justice to by those better able to handle them than myself.

HYDRAULIC PROPELLER.—Mr. Henwood believes it possible that the hydraulic propeller may prove more suitable for ships of war than the screw, that liquid fuel may supersede coal for generating steam, and that an efficient plan for sheathing the bottoms of our iron ships with zinc may be discovered. Considering that these at present unsolved problems may, and undoubtedly will, cause another reconstruction of our navy, involving an expenditure of £12,000,000 or more, Mr. Henwood believes it most unwise to lay down at the present time iron-clads which will take 2 or 3 years to complete, at a cost of £30,000 apiece.

NATIONAL LIFEBOAT ASSOCIATION. — The National Lifeboat Association state that since their last report 21 new lifeboats have been, or are about to be, placed on the coasts of the United Kingdom and the Channel Islands. Carriages and boathouses have been likewise provided for nearly all the boats. The institution has now 220 lifeboats on the coasts of Great Britain and Ireland and the Channel Islands. During the past year these boats have rescued no less than 871 persons from various wrecks; nearly the whole of whom were saved under circumstances which would have precluded their being saved by any ordinary boat.

THE Elevated Railway in Greenwich street broke down recently under the tests applied by the engineer. The directors promise an early opening to the public.

LOAD-DRAUGHT OF MERCHANT SHIPS.*

From "The Mechanics' Magazine."

The proper draught for a merchant vessel, said the author, is not a question to be determined in the first place by science, but by experience. Science may lend her aid, in generalizing the results of experience, but must unhesitatingly accept the dicta of those whose position and long practice make them the real arbiters of the question. The naval architect and ship-builder must bow, like others, to the decision of these experts. The load-draught cannot be arbitrarily fixed by the naval architect. Lloyd's rules, 3 in. to the ft. depth of hold, or the scale of the Liverpool underwriters, may be quoted; but these blind no one. Lloyd's rule was a suggestion only, and it was made when iron ships were just being talked of, and when few ships, except East India men, exceeded 700 or 800 tons, and it has never been recognized by Lloyd's Committee, except as an approximate guide for the loading of certain classes of vessels. The Liverpool scale is only intended for first-class vessels, and is subject in all cases to the judgment of the surveyor, who is influenced by the age and class of the vessel, its general proportions, the intended voyage, the nature of the cargo, and other circumstances, favorable or otherwise. The experts who practically rule in these matters are certain surveyors more or less intimately connected with the underwriting bodies, and who, if not practically appointed by shipowners, have secured their confidence. Their great experience enables them to judge very closely as to the draught of water at which a ship begins to damage her cargo or become otherwise unsafe. Wooden vessels are now passing away and iron sailing ships are being largely superseded by steamers. Iron sailing vessels will in future be chiefly employed in long voyages, and new ones will probably be of large size. As regards iron vessels, therefore, considerations depending on their age, the nature of the voyage, the season of the year, as affecting their load-draught, may be omitted nearly altogether. Considerations arising from the kind of cargo may also be omitted, as it is generally acknowledged that, with proper care, and by incurring the expense necessary for making good stowage, any proportion of dead weight may be safely carried. There remain only those conditions which relate to form and proportion, and these, I submit, are sufficiently represented by adopting the customs' measurements and registered tonnage. The suggestion that $\frac{3}{10}$ of the whole displacement is a proper proportion for buoyancy was made years since by Mr. J. Jordan. The author then proceeded to refer to various tables bearing on the subject of his paper; and alluding to the requirement of more free side for large wooden ships than for small ones, he said that the reasons assigned for it were not applicable to iron ships. Large iron ships can be as strongly built as small ones. There can be little objection to the $\frac{3}{10}$ displacement scale for ascertaining when a sufficient quantity of cargo has been placed on board a vessel. But it makes no allowance for extreme length, or for the length and character of the waves which she may encounter. The surveyors state the extreme length in proportion to a vessel's other dimensions, must be considered; but, so far as I am aware, they have not defined to what extent. Like the surveyors, I have not come to any definite opinion on this subject, but wait for better instructions. Like other scales which point out, with more or less exactness, what is the proper load-draught for a vessel, they leave us in ignorance as to what amount of departure from it will render a vessel relatively unsafe or practically unseaworthy. After some observations as to the desirableness of some mode of ascertaining the point at which a ship becomes dangerously laden, the author concluded by the following practical suggestion: Let a round spot 9 in. in diameter be conspicuously painted on every vessel over 300 tons register on each side, midships, at a point through which a horizontal plane would pass which would cut off the upper $\frac{1}{4}$ of the vessel's registered tonnage when she is on an even beam. This would be useful in indicating pretty accurately when $\frac{3}{10}$ of the whole vessel are out of the water.

* Read before the Institution of Naval Architects.

In vessels about 500 tons this mark should be fully its own diameter above water. In vessels of 750 tons it would be $1\frac{1}{2}$ its own diameter above water. In vessels of 1,500 tons it would be 2 diameters above water, in larger ships $2\frac{1}{2}$ diameters. Here no kind of instrument would be required to make the observation. If the spot were very near the surface of the water the ship would certainly be very fully laden, if it touched the water she would be very deeply laden, if immersed or out of sight she would be dangerousiy laden. This would not hurt the ship-owner in any way. The proposed mark would indicate a fact, not an opinion.

A VALUABLE EXPERIMENT.

From "The Engineer."

A paper read last February before the Institution of Engineers in Scotland, by Mr. Peter Carmichael, constitutes so useful a contribution to the literature of steam boilers, that it deserves all the publicity we can give it. Two cylindrical double-flued, or Manchester boilers, made steam at Dens Works, Dundee, for 19 years. These boilers were precisely alike, and of the following dimensions: Length, 25 ft.; diameter, 7 ft.; diameter of furnace end of flues, 2 ft. 9 in.; diameter of back end of flues, 2 ft. $4\frac{1}{2}$ in. The shell was made of $\frac{3}{8}$ in. "Glasgow best" iron, the flues of "Glasgow best scrap," also $\frac{3}{8}$ inch thick, the end plates were $\frac{7}{16}$ in thick. In June, 1867, certain repairs had to be effected in these boilers, and Mr. Carmichael found that the plates had become very brittle. The boilers were made by Messrs. Carmichael and Company, Ward Foundry, Dundee, and to them Mr. Peter Carmichael wrote. He received a reply to the effect that from experience the firm found that all qualities of iron get hard and brittle after the boilers have been at work more than a dozen years, more especially where exposed to the action of the fire; and that in the furnaces, even Lowmoor or Bowling iron becomes as brittle as common iron in that time, and great care has to be taken in making repairs to prevent the plates from cracking. For this reason they thought 16 or 17 years a long enough period for a boiler to be in use, at a pressure of 40 lbs. to 45 lbs. If used for a longer time the pressure ought to be lowered.

The boilers were kept in work until the beginning of November, 1869, when it was resolved to take out one known as "No. 9," and to test it to destruction by water pressure. The following are the particulars of the test as given by Mr. Carmichael. We may premise that the makers of the boiler, being consulted on the subject, reported thus:

"In the case of the above boilers the pressure has never been so great as 60 lbs., and as our boiler-maker reports that they are not wasted, have always been kept in good repair, and have stood the water test periodically up to 60 lbs. pressure, we would not apprehend any danger from working them a year or two longer. The fact of the iron getting hard and brittle after being in use for a length of time has often been pointed out to us by our boiler-maker of late; and, in consequence, we generally recommend that, in cases of high pressure boilers, the pressure be lowered, or new boilers introduced, after they have been working from 16 to 17 years."

Before testing, all the brick flues were taken down, so that easy access could be got to all parts of the boiler, but it was left sitting on its natural seat. The boiler was then filled with water at about 120 deg. temperature, and a hydraulic pump was then attached. To check off the pressure no fewer than five pressures gauges were put on, four of which nearly indicated the same pressure and tallied with the safety-valve. At 80 lbs. pressure per sq. in. an examination was made, and all appeared to be right; but as soon as the pump was started again the joint of the safety-valve was blown out, and this stopped proceedings for a time. After this joint had been tightened the pressure was again brought up, and at 85 lbs. the joint of the feed pipe at the front end of the boiler began to leak, owing to the bulging out of the end. At 100 lbs. a number of the longitudinal seams of the shell began to "weep" badly. The pressure was then removed, and the ends gauged above and below the flues; and, on the pressure being again put on, the following was the

result: Front end, below flues, bulged out in centre, $\frac{3}{16}$ in. at 35 lbs. pressure; do., do., do., $\frac{6}{16}$ in. at 100 lbs. pressure; front end, above flues, bulged out in centre, $\frac{4}{32}$ in. at 35 lbs. pressure; do., do., do., $\frac{7}{32}$ in. at 100 lbs. pressure; back end, below flues, bulged out in centre, $\frac{4}{32}$ in. at 35 lbs. pressure; do., do., do., $\frac{5}{32}$ in. at 100 lbs. pressure; back end, above flues, bulged out in centre, $\frac{4}{32}$ in. at 35 lbs. pressure; do., do., do., $\frac{5}{32}$ in. at 100 lbs. pressure. The pressure was then brought up to 105 lbs., when the ring seam at the back of the taper of the left-hand flue began to crack, and the pump became unable to keep up the pressure, owing to the great leakage. This joint or seam, when gauged, before testing, measured 2 ft. $3\frac{3}{4}$ in. horizontally by 2 ft. 5 in. vertically; and it gave way by crushing inwards on the flat or horizontal side, and remained flattened after the pressure was removed.

This boiler was then removed and sent to the foundry for breaking up; Mr. Carmichael proceeded to clear away the brick flues from the sister boiler. On the 15th December, 1869, it was tested in the same way, having been in use for rather more than 19 years. The flues were gauged, and were found, with one exception, similar to those of No. 9. The exceptional one being $1\frac{1}{2}$ in. oval, it was attempted to support this flat part by fixing a batten in the line of the shortest axis of the ellipse; but this was not found to be of any use, as the plate bulged out below one end of the batten and above the other, and loosened it when the strain came on. The pressure was noted as before: At 60 lbs. pressure the feed-pipe began to leak, the end bulging out $\frac{1}{16}$ in., as before. At 80 lbs. the feed valve-joint leaked very much, and the longitudinal seams of the shell began to "weep." At 90 lbs. the south, or right-hand flue began to crack, as if giving way. At 95 lbs. one of the joints of the shell, first rings, on the crown of the boiler, commenced to spout water, and the pressure could not be kept up, the leakage being equal to the supply of the force pump. The joints of the feed-valve were then tightened, and also some parts of the shell caulked, the right-hand flue being found to be very much flattened. The pressure was again put on, but it could not be got higher than 80 lbs., as the flue had given way so much as to allow the water to escape as fast as it was forced in; so that the highest pressure attained was 95 lbs., and this pressure had so injured the joints and flattened the flues as to render further experiment impossible. When taken off their seats, neither of the boilers was found to be corroded, either on the shells or flues; in most places the corners were as sharp, and the skin of the plates as fresh, as when they left the hands of the boiler-maker 19 years ago.

These two experiments are eminently instructive, throwing, as they do, considerable light on the fact that old boilers, apparently strong and sound, give way sometimes without the slightest previous warning, simply because of the deterioration of the iron by use; a deterioration, we may add, the occurrence of which has been flatly denied by many engineers in the face of a host of facts to the contrary. It also shows that it is not prudent to accept the rules commonly laid down as to the strength of boilers without qualification. According to Fairbairn's rules, the bursting pressure of these boilers was about 300 lbs. on the sq. in., yet they failed with one-third of this pressure. Whether they would or would not have withstood the pressure when new, it is impossible to say; but judging by the fact that the only deterioration they manifested was in the quality, not in the thickness, of the plates, the chances are that they would not, as brittleness—in other words, absence of powers of extension—is by no means incompatible with a high tensile strength if the strain be gradually applied. At all events we have it demonstrated that boilers should not be worked more than 15 or 16 years under any circumstances. Mr. Carmichael read a part of a report from the boiler-makers who broke the boilers up. So brittle were they that it was found almost impossible to get some sound test strips, which were sent to Mr. Kirkaldy. The rivet heads on the outside of the boiler flew off when the inside heads were struck by the hammer and set, so that the material of the rivets had deteriorated as much as the plates. As to the original strength of the plates, Mr. Kirkaldy, in "Experiments on Wrought Iron and Steel," gives at p. 150, the tensile breaking strength per sq. in. of original section as follows: Glasgow best boiler plate, drawn in direction of

fibre, 24.04 tons; do. across, 21.8 tons; Glasgow best scrap plate, 22.7 tons; mean, 22.92 tons. The test strips cut from Mr. Carmichael's boilers gave the following results: Shell plates, direction of fibre, 19.7 tons; do. across, 19.2 tons; mean, 19.45 tons. Furnace plates, direction of fibre, 17.1 tons; do. across, 15.3 tons; mean, 16.2 tons. It will thus be seen that, according to this report of testing, compared with Mr. Kirkaldy's table, while the shell plates have deteriorated or weakened from 22.92 tons to 19.45 tons, the furnace plates are decreased in strength from 22.7 tons to 16.2 tons. It must not be forgotten, however, that nearly all Scotch iron is cold short.

We trust that many other firms will follow the excellent example set by Mr. Carmichael, and, when possible, test their rejected boilers to destruction as he has done. Even if they will not incur this expense, we invite them to send test strips from the broken-up boilers to Mr. Kirkaldy. A score of experiments of this kind would supply an enormous amount of information of the utmost value to engineers. Mr. Peter Carmichael deserves the thanks of the profession. He has ours.

ON THE DRESSING OF LEAD ORES.

From "The Artizan."

In a paper lately read before the Institution of Civil Engineers, the author, Mr. T. Sopwith, Jr., described some works he had recently established in Spain.

By dressing was to be understood the art of obtaining from the raw material extracted from the mine, called bouse, or mine stuff, the pure ore it contained, to the rejection of the impurities with which it was associated. Bouse might be said to yield, in an ordinary way, from 5 per cent. to 25 per cent. of galena, which when pure had a specific gravity of 7.75, and produced 86 per cent. of metallic lead. The lead ores of commerce were usually dressed to a tenor of from 74 per cent. to 78 per cent., though argentiferous ores were frequently delivered with a lower percentage. All galena was mixed with silver; but the term argentiferous was only applied to that in which there was upwards of 12 oz. of silver per ton. In dressing, the principle applied was that of separating the lead ores by means of their readier gravitation. This operation was easy or difficult according as the accompanying impurities were of greater or less specific gravity.

At the works referred to, about 350 tons of lead ore were prepared per month. There were two dressing floors, the higher and the lower. On the former, manual labor was principally employed. On the lower floor the stuff was treated which required to be passed through the crushing mill; and it was more particularly this machinery and method that it was the purpose of this paper to describe. On the higher floors from 200 to 220 tons per month were prepared, or two-thirds of the entire quantity. Two systems of paying the miners were adopted in mineral mines: one, by "tribute" or "bingtale," where the men were paid in proportion to the amount of clean ore the mine stuff excavated by them produced; the other, "tutwork" or "fathomtale," where they were paid by measurement. The adoption of the former system introduced complication, and more expense in the dressing operations than the latter.

The author, in describing the various machines, and the quantities of work they could deal with, fixed as a standard the richness of mine stuff treated at about 12 per cent. (by weight), equal to work which would be known in the North of England as producing 2½ bings per shift.*

The washing operations commenced by turning a stream of water into the "teams" containing the "bouse," which was raked out by a man on to a grate and there hand-picked. The author used two grates; the higher one with spaces of 1 in., and the lower one of ½ in., in preference to the one grate with spaces ¾ in. wide, as usually employed. The stuff passed through the second grate into a stirring trunk, where a partial separation of the coarser particles from sludge and slime

* A bing is 8 cwt. A shift is 8 wagons, carrying about one ton each.

was affected. The coarser particles were of a size convenient for hotching, and the common hotching tub could treat from 8 tons to 15 tons of stuff per day. Between the waste, which was wheeled away, and the pure ore, there was an intermediate layer of what was called "chatts," consisting of particles mixed with ore which could not be separated without further subdivision. This was effected by means of a crushing mill. In England from 25 tons to 30 tons was a fair day's work to pass over one grate. The author found, by the use of two grates, that 40 tons could be passed, without any increase of labor, at a cost of about 2s. 6d. per ton of clean ore produced.

The ore which passed through the coarse wire bottom of the hotching sieve, accumulated at the bottom of the tub, and was called "smiddum." This was rendered fit for market by further preparation in a plain buddle. The sludge deposited in the trunks attached to each grate was prepared in a round buddle. A separation having first been made of hard lumps, small stones or chips of wood, etc., the sludge was delivered at the centre of the buddle accompanied with water. The bottom being inclined outwards about 1 in 10, the particles were carried by the water in that direction; the heaviest and richest being deposited nearest the centre. The buddle described was larger in diameter, and treated nearly four times more stuff, than that usually employed. The water, on leaving the sludge trunk carried with it a certain amount of slime, which was deposited in pits, and was subsequently treated in a machine called a Brunton's cloth, the action of which was described, as also of the dolly tub, by which the slimes, after being concentrated in the Brunton's machine to about 45 per cent., were further enriched to about 70 per cent., and so delivered for sale. The crushing mill in common use in England was described, and the inconvenience attached to it, as compared with the simpler form used in Germany, was pointed out. In the apparatus that had been referred to, it was probable that about 80 per cent. of the lead ore produced in England was prepared.

On the lower or crushing mill floors, which the author had erected, some attempt had been made to secure continuity of action, by the use of self-acting machinery, wherever it was possible; though from the circumstance of Spanish laborers being employed, who were totally unaccustomed to the use of machinery, it was necessary that the machines should be of the simplest kind. The stuff which required crushing was conveyed in wagons to the lower floors, being first broken to a size which would pass through a 5-inch ring. This was effected by manual labor, in preference to a stone-breaking machine, as the former allowed of a separation of a small quantity of pure ore, and of a large quantity of waste, which would afford unnecessary work for the crushing mill. The stuff, after being emptied from the wagons in the hopper of the crushing mill, was passed through the rollers, and, when crushed, was elevated by a Jacob's Ladder, and delivered into a classifying trommel, composed of two shells, an outer one of perforated iron plates with holes of $1\frac{1}{2}$ millimetres in diameter, and an inner one with holes of 10 millimetres in diameter. The crushed material was delivered in the inside of the trommel at one end, and passed onwards, the trommel being inclined. All the sludge and slime were got rid of through the outer shell, the inner shell retaining and delivering apart any particles over 10 millimetres in diameter. These were returned to the crushing mill, to be again passed through the rollers, and the particles, ranging in size between $1\frac{1}{2}$ millimetres and 10 millimetres, were delivered at the further end of the trommel, and passed on to a second, or sizing trommel, composed of one shell only, and were then subdivided into four sizes, viz., $2\frac{1}{2}$, 5, $7\frac{1}{2}$, and 10 millimetres, each size being treated in a separate hotching tub. For the operation of hotching, the convenience of having all the particles treated of one, or nearly of one, size, was obvious; and in some cases of refractory ores it was a necessity. The hotching machines employed were entirely self-acting, and continuous in action; a fast and a loose pulley being attached to each machine. Contrary to the form adopted in England, the sieve was stationary, the water being put in motion by means of a loosely fitting piston. The stuff was delivered into a small hopper, and travelled the length of the sieve, a distance of 28 in., by which time a perfect separation was effected. It had been found advantageous to increase the length of the

stroke, and the number of strokes per minute, for the larger sizes. By an ingenious movement, a quick down stroke and a slow return stroke had been given to the piston. The crushing mill was more compact than the form used in England, the rollers being kept in contact by the compression of india-rubber buffers, in place of a long lever, with a heavy weight attached. The sludge, which passed through the holes of $1\frac{1}{2}$ millimetres in diameter, in the first, or classifying trommel, was delivered into a separator—an iron cylinder about $2\frac{1}{2}$ ft. high—where it met a stream of water of sufficient strength to carry the smallest and lightest particles upwards, and deliver them into a launder, whence they were conveyed, by the water, to the sludge trunks and slime pits, and were subsequently treated in round buddles and in Brunton's cloth. The coarser particles were prepared by manual labor, in a common trunk or tie.

The amount of work crushed and prepared on the lower floors was about 55 tons per day of 10 hours. The actual cost in Spain was 21s. 2d., but the equivalent of labor would be performed in English mining districts for 13s., the latter sum being at the rate of 2.83 pence per ton of raw material treated, or 2s. per ton of clean ore produced. If, however, self-feeding apparatus was introduced to supply the hotching machines, which could easily be done, the latter cost might be reduced to 2.07d. and 1s. $5\frac{3}{4}$d. respectively. The cost of preparing similar work in England, with machine crushers and machine hotchers, was, the author believed, about 2s. 6d. per ton of clean ore. The whole of this machinery was driven by a 10 H.P. portable engine, supplied by Messrs. Ransomes, Sims & Head. The cost of erection of the crushing mill floors complete, including the engine, was about £1,500. The same arrangement in England would have cost about £1,200. Most of the machinery was supplied by Messrs. Sievers & Co., of Kalk, near Cologne. No separate crushing mill for the preparation of "chatts" had been erected, as when the "chatts" had been allowed to accumulate, the present machinery could be adapted for their treatment in an hour or two, advantage being taken of a time when new rollers had been put in.

The author observed that whereas, in England, the machinery employed in dressing operations was for the most part made at the mine with the ordinary staff, in Germany there were manufactories giving employment to 400 hands, dedicated almost exclusively to the construction of dressing machinery; and it was not surprising to find, in the machines issued from them, better proportions, greater elegance, and more efficiency and durability than those used in the mines in this country.

The machinery described in this paper had been in use for two years, and having given good results in Spain, no difficulty need be feared in its application elsewhere.

BRITISH INDIAN SUB-MARINE CABLE.

From "The Mechanics' Magazine."

When the enormous length of cable in connection with this enterprise is considered, it is a matter of great congratulation to all that the entire amount should have been submerged between Bombay and Suez without any serious hitch. Up to the present no expedition has been attended with such unqualified success, and in all probability it will be found to materially improve the prospects of submarine telegraphy. Of the advanced stage of confidence in deep-sea cable laying, no greater proof can be given than the small amount of space allotted to the progress of this work in the daily press; beyond the usual telegrams announcing the gradual progress of the work, little or no mention has been made. This is a matter of some little surprise, for the present cable exceeds in length that of any cable previously laid.

The entire amount of cable was completed on December 11 last, and the last section shipped some time later, but this would at first seem to show some delay in the prosecution of the work; that, however, was not the case, for the entire work has been completed within the time specified by contract. The first great object was to get the Great Eastern away in

time; this was successfully accomplished, and the remainder of the cable sent away with the appointed ships.

The following vessels were engaged in the work: Great Eastern, Hibernia, Chiltern, William Cory, and Hawk, and the stowage on board of the different types was as follows:

GREAT EASTERN.

	knots.
Type D, Bombay shore end	10
" B, intermediate	70
" E, second ditto	86
" C, main cable	1,874
" D, Aden shore end	10
Bombay-Aden section, total	2,050
Suez-Aden section—	
Type B, intermediate	325
	2,375

CHILTERN.

Type D, Aden shore end, Suez-Aden section	10
" A, main cable	250
	260

HIBERNIA.

Type A, main cable, Suez-Aden section	613

WILLIAM CORY.

Type A, main cable, Suez-Aden section	312

HAWK.

Type D, Suez shore end, Suez-Aden section	10
Total	3,600

The Great Eastern, accompanied by the Chiltern, made a successful passage round to Bombay; the Hibernia, with her section, was timed to arrive at Aden on the completion of the Bombay-Aden section; the William Cory and Hawk departed still later, and going to Suez by the Lessep's Canal, were to arrive there and begin paying out, so as to meet the expedition in the Red Sea, near the Dædalus Light. It will be seen how excellent were these arrangements and how well carried out.

The coaling and other necessary arrangements having been completed at Bombay, the Chiltern first laid the shore end on February 7, and buoyed it. On the 14th the two vessels proceeded together to the buoy on the end. The Chiltern lifted the end, and having received the end of the cable from the Great Eastern, the splice was made and slipped. Paying out from the Great Eastern commenced at once, and continued throughout the night; and at noon on the 15th, 98.5 miles were payed out, with a percentage of slack of 2.7; and at 8.38 P. M., the splice on to the deep-sea cable passed over the stern. On the 16th the depth had increased to 1,876 fathoms; and at noon of the 17th, to 2,170 fathoms—359.7 knots being payed out with 9.6 per cent. slack, and at an average speed of about 5.4 knots per hour.

The weather throughout was fine, and paying out continued uninterruptedly, no accident or mishap occurring, the only stoppages taking place when the shift of tank became necessary; these were accomplished quietly and without difficulty. On the 26th the Chiltern went forward to mark the point for terminating the deep-sea cable and the commencement of the intermediate type. On the Great Eastern joining her, the cable was cut and the intermediate spliced on, and about 20 miles of intermediate being payed out, the end was buoyed on the morning of the 27th, there being too much wind and sea for laying the shore end, up to this point a total length of 1,808 knots having been payed out. Some slight delay was occasioned through bad weather, but on March 2 the shore end was laid and the final splice made, the tests throughout continuing perfect. The exact length payed out being 1,818.16 knots, leaving a surplus amount of cable of 231.84 knots, showing that more than ample provisions had been made, not alone for slack, but in case any accident should happen.

The day following the completion of the Bombay and Aden section, the Hibernia made her appearance at Aden and preparations were at once made for immediately laying the Red Sea section. The shore end from Aden was laid by the Chiltern, and on March 6 the expedition started. The end from the Great Eastern was taken on board the Chiltern, and the splice between it and the shore end was made and paying out commenced next evening. All went on satisfactorily, and at noon next day,124 miles had been payed out with only about 2 per cent. slack, owing to the shallowness of the water. On the 8th, at midnight, the Great Eastern's section of 325 miles was completed and buoyed, and on the following morning the Hibernia lifted the end and spliced it on to her cable, and immediately afterwards commenced paying out. On the 13th the Hibernia had completed her task and paying out was started from the Chiltern; it was originally intended that the Chiltern should complete the work, it having been

arranged that the Hawk should lay the shore end, and the William Cory pay her cable out towards the rendezvous near the Dædalus, but some delay having occurred, the Chiltern arrived there first; it was consequently determined to pay out all her cable, which was accordingly done, and the end buoyed on the 15th March. The Chiltern remained by her buoy, which was let go in 388 fathoms and about 100 miles on the Suez side of the Dædalus, while the Hibernia went in search of the paying out vessels from Suez. These were come in sight of and paying out was going on successfully, and the William Cory arrived off the buoy, but owing to unfavorable weather the final splice was not made until March 22d.

In contemplating the present work, there are several points which immediately claim attention. The first of these is undoubtedly the wonderful success attending the work, especially as regards the entire absence of electrical faults. From the commencement of the paying out at Bombay to the completion of the work, the final splice in the Red Sea representing a length of over 3,000 miles of cable, the electrical tests gave the condition of the cable as perfect, and the insulation constantly improving—not a single hitch, not a sign of a fault; the longest length of cable hitherto laid completed without any *contretemps* beyond that due to weather. It is certainly a wonderful success, and the accomplishment of this work must be looked upon with universal gratification.

Hitherto the accidents and faults that have occurred have been most beneficial; they have proved beyond doubt that when they do occur, there is a certainty in repairing them even in deep seas; they have consequently given great confidence in the facility of laying and repairing deep-sea cables, but there is certainly more satisfaction in having a long cable laid without the occasion of putting these proofs to the test.

It is not long since we chronicled the successful completion of the French Atlantic cable. The present cable exceeded only by a few miles the length of that cable, and as regards the deep-sea portion, was somewhat less. The present cable has been completed without a hitch or fault. The French Atlantic cable had several faults, all occurring in the deep-sea cable. The electrical testing was watched carefully throughout in both cables, and it may be safely asserted that there was not a single electrical fault in either cable before paying out commenced. It may still be asked—why should faults occur in one and none in the other? The structural appearance of the cables may answer this question. We cite the French Atlantic cable, but the older Atlantic cables may do as well. Similar faults made their appearance in them, and which have before now been attributed to maliciousness—a reason we cannot agree with.

The Atlantic type of cable consists of a sheathing of homogeneous iron wires served with strands of hemp. In places this wire is brittle and elastic. It frequently breaks and springs up. What more probable than its piercing the layer of cable above or below it, and penetrating as the cable is payed out—the sudden jerk breaks off a short piece, leaving it sticking in; the bearings it passes over in paying out will complete the mischief, and make a fault while at the same time frequently removing the cause. In almost all the cases that have occurred, the signs have been the same, and the cause has also been seen.

Why should not the same things have occurred with the present cable? The original type is the same as that described, but it is also added to. After the cable had been sheathed with its strands of hemp and steel, it received a thin serving of hemp in an opposite direction, and then passed through a bath of Clark's compound, binding the whole up so firmly that even if a wire did break, it could not possibly escape and do damage. There can be no question that this new form of cable has added most materially to the success of the expedition—a success which, we are glad to observe, reflects the greatest credit upon all the persons engaged, and probably upon none more than upon the organizers of the expedition.

A GREAT discovery has been made in Bengal. Coal has been found at Midnapoor while boring for water for the use of the gaol. It is not impossible that further borings may establish the existence of a coal field beneath the laterite formation, that extends from Ranigunge to Midnapoor.

PROPOSED NEW MODE OF LAYING AND RAISING SUBMARINE TELEGRAPH CABLES.*

Messrs. Sidney E. Morse and G. Livingston Morse, of New York, propose a new method of laying submarine telegraph cables. Submarine telegraph cables have hitherto been laid, as nearly as possible, in one continuous straight line on the bottom of the sea. It is obvious that when a cable has been thus laid, it cannot be raised from the bottom to the surface in the deep sea without breaking it, and then raising successively each of the two parts, and that it cannot be repaired there and relaid without splicing to the two broken ends new cable of a length equal to at least twice the depth of the sea at that point. Messrs. Morse propose to lay the cable on the whole line, in the first instance, in such a way that it can be raised at any time for repair, or for any other purpose, at any assigned station or stations on the line, and then relaid, without breaking it.

In laying a submarine cable entirely across the ocean, Messrs. Morse propose to employ two vessels. The first and larger vessel is to carry the telegraph cable in any required length, either enough for the whole line, or for one or more sections of the line, as may be desired, together with the ordinary apparatus for laying this cable on the bottom of the sea. The second and smaller vessel is to carry, first, a lifting cable, long enough at least to reach the bottom of the sea at the deepest point on the line, and strong enough to support a weight equal to the weight in water of ten miles of the telegraph cable, if the depth of the sea on any part of the line should be as much as two miles, and proportionally stronger if the water should be deeper, this lifting cable having firmly attached to its lower end a strong, heavy iron ring, seven or eight inches or more in diameter; and, secondly, as many properly constructed iron hooks as there are stations on the line, at which provision is to be made for raising the telegraph cable ; each hook to be strong enough to support the ten miles or more of telegraph cable ; the shank of each hook to be provided at short intervals with five, six, or more barbs, all pointing downwards, but in various directions, each barb being as stout and strong as the hook itself, and the shank terminating in an eye, in which is firmly fastened the end of a galvanized iron wire rope ; it may be five or ten miles long, or more, and between one-eighth and one-fourth of an inch in diameter ; the strands of this wire rope to be untwisted at suitable intervals to embrace wooden cases in the form of cylinders, about four inches in diameter and of indefinite length, but with tapering, conical ends ; the cylindrical part of each wooden case to contain a sufficient number of three-and-a-half inch hollow glass spheres to give the wire rope any required buoyancy at any required intervals.

Thus freighted the two vessels leave a terminus, let us suppose, in France, to proceed along the arc of a great circle, nearly due west, to Newfoundland, a distance of about 2,000 miles, to lay the telegraph cable so that it may be raised at any future time without breaking it, at any one of 19 stations 100 miles apart. The smaller vessel goes ahead on a nearly due west course, and is followed by the larger vessel, from which the telegraph cable is payed out and laid on the bottom of the sea in the usual way. After the smaller vessel has proceeded 100 miles it stops, turns with its bow to the north, and, one of the hooks having been suspended from its stern, with the ring at the end of the lifting cable under one of the barbs on the shank of the hook, waits for the larger vessel, which, as it passes on its westerly course, deposits its cable in the hook and proceeds until the telegraph cable rests again on the bottom, leaving a certain length suspended from the stern of the smaller vessel in the form of two catenarian curves, extending each from the hook to the bottom of the sea, one in an easterly and the other in a westerly direction. If the depth of the sea at that point should be two miles, the speed of the larger vessel in laying the cable could be so regulated that the span between the two points at which the cable would touch the bottom would be eight miles, and in that case the length of cable

* From the Report of Prof. S. F. B. Morse, LL. D., U. S. Commissioner to the Paris Exposition.

included in the two catenarian curves would be about nine miles, and the hook and lifting-cable would support nine miles of telegraph cable at the stern of the smaller vessel. The smaller vessel should then proceed due north for two miles, the lifting-cable meanwhile being allowed to sink and unwind itself from a reel till the whole of the 9 miles of telegraph cable included in the catenarian curves is deposited on the bottom of the sea, as nearly as possible at right angles to the general course of the rest of the line. The lifting-cable should then be made, by the weight of the ring at its end, to detach itself from the hook, and should be drawn up and wound again around its reel in the smaller vessel, which should all the while be continuing on its course due north paying out the iron-wire rope and its inclosed glass-sphere buoys to any desired distance—5 miles, or 10 miles, or more if deemed expedient. The galvanized iron wire rope should be made to terminate in an anchor, and when this anchor is dropped in the sea the rope may be made, by a previous proper disposition of the glass-sphere buoys, to assume any desired form, either that of one long arch or of a succession of arches, rising in the water from the bottom, and as near the bottom or as far from it as may be deemed best. The deposit of the anchor at the end of the galvanized iron wire rope completes the laying of the first section of the line, and the other sections may be laid by repeating the whole process.

The process of raising again to the surface a telegraph cable thus laid is very simple. The latitude and longitude, both of the hook and of the anchor of the wire rope, it should have been remarked, must be accurately taken when they are deposited on the bottom of the sea. When the telegraph cable is to be raised, the smaller vessel, with the lifting cable on board, and a small line, long enough to reach nearly to the bottom of the sea, and having a small hook or grapple of proper construction at its lower end, must be sent to any point of latitude between the latitude of the hook and the latitude of the anchor of the wire rope, and to any meridian within a few miles either east or west of that on which the wire rope is floating below, supported by the encased glass-sphere buoys. With the small line depending from its stern, and extending, with its sinker and hook, nearly to the bottom of the sea, the vessel must then be moved to the east or to the west, till this line shall cross the wire rope and bring it to the surface. When brought to the surface the wire rope must be parted, and the part connected with the anchor temporarily buoyed, while the end of the other part is taken on board the vessel, and, after passing the heavy iron ring of the lifting cable over it, must be held on board until the ring carries the lifting cable down to the bottom, the wire rope guiding it till the ring passes the bars on the shank of the hook which holds the telegraph cable in its grasp. Then, by drawing up the lifting cable, the ring will catch under one of the bars of the hook, and by continuing to draw up, while the smaller vessel is moved 2 miles on a southerly course, or on a course directly opposite to that pursued in laying it, the part of the telegraph cable included originally in the 2 catenarian curves will be raised again to the surface without being broken.

Among the advantages of this mode of laying submarine telegraph cables are the following :

1st. All risk of losing the cable while laying it is avoided. More than 300 miles of the Atlantic telegraph cable of 1857 were finally lost, and more than half of the Atlantic telegraph cable of 1865 was temporarily lost, while the operators were in the act of laying them. These losses would not have occurred if those cables had been laid on the plan here proposed and described. After the parting of the telegraph cable in each case the vessels would have returned to the last raising-station with a lifting-cable, and after raising the telegraph cable from the bottom to the surface at that point the operators would have underrun the raised part till they had come to the broken end, spliced this end to the broken end of the cable in the ship, and proceeded with the work of laying the cable on the bottom.

2d. The risk of losing the cable after it has been laid is divided by the number of raising-stations on the line. The Atlantic telegraph cable of 1858, although successfully laid through its whole line, after a few days of feeble life was totally and finally lost. No one knows where or what was its malady. It may have been

confined to a few feet or to a single point on the line. If it had been laid on the plan herein proposed the place of the fault might soon have been found, the defective part might possibly have been easily removed, and the whole cable restored to permanent and efficient life.

3d. The danger of encountering storms and fogs while laying the cable is avoided. On the plan proposed by Messrs. Morse the cable is laid by sections, and after one section is laid the work may be left for weeks, or for any length of time, and then resumed. The sections may be of such length that a single section can be laid in a single day; and, if the day is judiciously selected, embarrassment from the weather will rarely occur, and, when it does occur, will be of comparatively little importance; but when the cable is laid in one continuous line for 2,000 miles without stopping during the 14 days necessary to lay such a length of line, experience proves that it will be very difficult to avoid serious embarrassment from the weather, even in the most favorable season of the year.

4th. Less length of cable will be required to connect the termini of the line. The length of cable actually used to connect the termini in Ireland and Newfoundland of the Atlantic telegraph cable of 1858 was about 15 per cent. greater than the distance of the two points from each other, measured on the arc of the great circle between them, and, in the cable of 1866, it was about 12 per cent. greater. As this distance in each case is nearly 2,000 miles, it is clear that more than 200 miles of telegraph cable were lost by *unnecessary slack* in attempting to lay the cable across the Atlantic Ocean in one continuous straight line under circumstances uncommonly favorable to economy in the length of cable used; for, in 1866, the weather was so favorable that the ships deviated very little from the true line in their course. The loss of these 200 miles is not merely the loss of the cost of so much cable, but, as more words could be transmitted through the cable in any given time if it were 200 miles shorter, the loss will continue to be felt through the whole life of the cable in the diminution of its capacity to earn income. If the cable had been laid in sections, on the plan proposed by Messrs. Morse, and had been carefully and deliberately laid upon that plan, after soundings at very short intervals along the line with the aid of the bathometer of Messrs. Morse, it could have been made to conform so accurately to the arc of the great circle, and to all the swells and hollows of the bottom of the sea, that the slack might have been almost confined to the stations at which it would have been purposely made, in order to furnish at those stations the necessary means for raising the cable from the bottom to the surface without breaking it. The loss of cable by slack at one of these stations, a loss by which an advantage so desirable is gained, need be only one mile, even when the water is two miles deep, as has been already stated in the account of the Morse process of laying the cable. The loss at 20 stations need, of course, be only 20 miles, or less than $\frac{1}{10}$ part of the length superfluously expended in the method hitherto pursued in laying submarine telegraph cables.

Instead of a lifting-cable, Messrs. Morse propose, in some cases, to send down, to be attached to one of the barbs on the shank of the hook, a buoy, composed of very large hollow glass spheres, inclosed in a tube, the spheres being sufficient in number and buoyancy to support and raise through the water to the surface the whole of that part of the telegraph cable included originally in the catenarian curves. They would put the heavy iron ring over the end of the galvanized iron wire rope held on board of the vessel, and then attach the buoy to the upper side of the ring, while to the lower side they would attach a weight sufficiently heavy to draw the buoy slowly to the bottom. After the ring, guided by the wire rope, has passed the barbs on the shank of the hook at its end (the hook which holds the telegraph cable in its grasp), Messrs. Morse would cause the weight, by a simple device, to detach itself from the ring, and the ring would then be drawn under one of the barbs by the buoy, which, at first very rapidly and afterwards slowly, would rise and draw the telegraph cable to the surface. The weight may be made at little cost by inclosing sand and stone in a bag, or in any suitable cheap material. By this mode of raising the telegraph cable the time and labor of men at a windlass would be dispensed with. The whole work would be performed automatically by the buoy and the weight, and at the expense only of the sand necessary to

sink the buoy from the surface to the bottom, and the cable would be raised far more speedily and satisfactorily by this process than it could be by human labor.

Messrs. Morse also propose to apply their above-described method of laying and raising a long galvanized iron wire rope, suspended by inclosed glass-sphere buoys in the form of an arch or arches near the bottom of the sea, to the end of a submarine telegraph cable laid in one continuous straight line from a station on shore to any assigned point of latitude and longitude in mid-ocean, which point would thus be constituted a telegraph station on the bottom of the sea, accessible for use by the master of any ship who should have a telegraph instrument on board, and a small line long enough to reach the bottom at that point, and who might be acquainted with the latitude and longitude of the mid-ocean terminus of this telegraph cable, and also with the latitude and longitude of the anchor at the outer end of the galvanized iron wire rope. Knowing these points, and allowing the small line with a sinker and hook at its outer end to run out from the stern of his ship till the hook approached the bottom, this ship-master would cross the galvanized iron wire rope with his small line, bring the rope on board, and, without breaking it, underrun it towards the telegraph cable till he came to the light insulated copper wire in which the telegraph cable, for a distance equal to the depth of the sea at that point, should be made to terminate, and then, by connecting this insulated copper wire with his telegraph instrument, he could send and receive communications to and from the shore. After doing this he might drop the iron wire rope and the light insulated copper wire into the sea, and they would automatically assume the position from which they were raised, and be ready to render their services to any other ship-master traversing that part of the ocean.

CYLINDERS FOR HYDRAULIC PRESSES.

From "The Engineer."

The hydraulic, or, as some persons erroneously term it, the hydrostatic press, was patented by Bramah in 1796. It has therefore been known to the world for 74 years, and is now applied in a multitude of operations, which absolutely could not have been performed at all without it. Presses exerting a force of 500 tons, and having ranges of 10 ft., 12 ft. or even 15 ft., and being capable of exerting the force we have named at any part of the stroke, are by no means uncommon. We do not stretch a single point when we say that no arrangement of screws or levers would supply us with a press of equal range, power, and speed. It is not that an arrangement of levers could not be planned quite able to exert the strain of which we speak; but such an arrangement would lack all the characteristics which are essential to a mechanical device intended to serve the purposes of manufacturers. For example, had the work done in raising the tubes of the Britannia Bridge been performed by a simple lever, one arm must have been 448,000 ft. longer than the other, and to enable a pound to raise the load through 100 ft., the pound must have passed through space for a distance of 83,522 miles. In simplicity, in cheapness, and in efficiency, the hydraulic press stands totally without a rival. Whether assuming the form of the gigantic apparatus employed in bending armor plates, or that of a little 30 cwt. jack, it is equally compact, inexpensive, and elegant. It is no matter for wonder that its use is rapidly extending. But it must not be assumed that the hydraulic press, as we have it, is perfect. It is by no means all that can be desired as regards two important features. In the first place, the leather packing of the ram is an endless source of trouble. In the second, it has hitherto been found exceedingly difficult to obtain perfectly sound and trustworthy cylinders, especially of large dimensions. On the subject of packing we shall say nothing now, having already dealt pretty fully with the question in a recent article. We shall confine our remarks for the moment to the questions involved, and the difficulties to be overcome, in the production of cylinders which will prove all that can be desired; and we believe it is in our power

to place many of our readers interested in the subject in possession of facts which they will find novel and valnable.

Obviously, the first thing to be secured in the construction of a hydraulic press is sufficient strength in the cylinder. In practice, hydraulic press cylinders have to withstand working pressures of from 1 to 4 tons per square inch, the latter being more nearly the ordinary pressure than the former. A cylinder 10 ft. long and 12 in. diameter would be called upon under the last-named pressure to withstand a bursting strain, tending to rip it up from end to end, of not less than 5,860 tons. The strength of boilers or other cylindrical vessels of thin iron can be determined by the formula

$$P=\frac{2\,S\,T}{D}$$

where P is the pressure, S the strain allowed to be put on each square inch of the metal, say 8,000 lbs. for ordinary boiler plate; T, the thickness; and D, the diameter of the plate. But this formula will not apply to thick cylinders, and we must then have recourse to that given by Professor Rankine,* which is

$$\frac{R^2-r^2}{R^2+r^2}=\frac{p}{f}$$

where R is the external, and r the internal radius of a thick hollow cylinder, the tenacity of whose material is f, and whose bursting pressure is p; consequently,

$$\frac{R}{r}=\sqrt{\left(\frac{f+p}{f-p}\right)}.$$

The formula given by Molesworth is, however, more convenient for general use. It is, let p be the pressure in tons per square inch, D internal diameter of cylinder, x constant for different metals, T, thickness of metal; then

$$T=\frac{\frac{1}{2}\,D\,P}{x-P}.$$

$x=7$ for cast-iron, 14 for gun metal, and 20 for wrought-iron. From this it will be seen that a cylinder of cast-iron 12 in. in diameter inside, and exposed to a pressure of 4 tons per inch, must have a thickness of 8 in. If gun metal were substituted for cast-iron the thickness would be 2.4 in., and if wrought-iron were used the thickness would be 1.5 in.

In practice, for obvious reasons, the lighter a hydraulic press can be made the better; it follows that wrought-iron would be the best possible material of which to make hydraulic presses, provided its use were not attended with counteracting disadvantages. Unfortunately it has hitherto been found impracticable to make hydraulic press cylinders of this material, because a straight longitudinal weld cannot be got to stand the enormous strain put upon it. It is just possible that hydraulic cylinders might be made on the coil system used in the manufacture of heavy guns, but if so made they would be very expensive, and there is a strong probability that they would not be uniformly successful, owing to a circumstance of which we have now to speak.

All the metals are more or less porous, and cast-iron in particular is so porous, that when the pressure reaches about 4 tons on the inch the water passes through the apparently solid walls of the press as fast as it can be pumped in by the very small plungers which must of necessity be used when the water is driven directly into the press cylinder by pumps. The accumulator press, described very fully in a recent impression, is not open to this objection, because the water is forced into it more rapidly than it can possibly escape, by the action of the differential ram. A cylinder made of coiled wrought-iron would probably suffer water to pass through its walls more rapidly than cast-iron, the flow taking place through the welds, which it is, practically speaking, impossible to make water-tight throughout. For these reasons no wrought-iron hydraulic press cylinders are made, so far as we are aware; nor does it appear that brass or gun metal possesses any advantage sufficient to counterbalance the enormous price, as compared with cast-iron, which a cylinder of either material would cost. But three materials are in ordinary use. These are cast-iron, steel, and malleable cast-iron. As regards the first, we have nothing new to say; as regards the second, although steel is sufficiently promising, up to the present comparatively very little has been done in the production of hydraulic presses by its aid. The steel can only be used in one way; any cylinder made of it must be cast as a cylinder; and the moment we come to

* "Machinery and Millwork," page 495.

deal with the great masses of metal unavoidably present in large presses, we encounter difficulties in using steel which greatly enhance the cost of manufacture. Very few establishments in the world, for example, could cast from pots a steel cylinder 15 ft. long and 12 in. or 14 in. in diameter inside. Krupp could no doubt turn out any number of pot steel cylinders, and Messrs. Vickers, of Sheffield with their splendid appliances, make not a few. That such cylinders are successful we see no reason to doubt ; but their cost is of necessity very much greater than that of cast-iron cylinders. On the other hand, it is urged, and with some show of reason, that at most, in the case of cotton presses, £100 sterling is about all the difference one way or the other between a press with a steel and a press with a cast-iron cylinder. And this sum represents such a fractional increase on the cost of packing each bale that it is of no moment whatever. That a properly made pot-steel cylinder must be better than cast-iron, in that it is lighter and is more easily carried up country in India or Egypt, and stronger, and therefore likely to last longer, is tolerably evident. The fracture of a cylinder in the midst of the packing season would cost its owner infinitely more than £100, if there was not a spare one ready at hand to replace the broken one. Very large steel cylinders might perhaps be made direct from the Bessemer converter at a very low price, but it is probable that the casting would be so porous that the water would escape through it more rapidly than through cast-iron. Bessemer metal is good for very little unless it is well hammered and consolidated subsequently to the act of casting. We do not say that it is impossible to design or construct machinery by which Bessemer steel cylinders of the size named above might be hammered and squeezed or otherwise consolidated after casting ; but we do assert that the cost of carrying out the process would be fatal to its commercial success. No great difficulty would be encountered in the production of *small* cast steel-cylinders. But one material remains for consideration—that is malleable cast-iron. This material when good possesses, according to Professor Rankine, a tensile strength of 48,000 lbs. to the square inch, equal to that of good wrought iron. It has been before the world for many years, and most of our readers are doubtless familiar with it as presented to them in the shape of small-toothed wheels and light castings of all kinds. Some of them will be surprised perhaps to learn that Messrs. McHaffie, Forsythe, & Co., of Glasgow, are able to produce castings weighing as much as 12 tons, which are suitable for hydraulic cylinders. The firm have devoted peculiar attention to the manufacture of such cylinders, and have succeeded in turning out some excellent pieces of work. The precise details of the process are preserved as a secret by the firm. It must suffice to say that we have recently examined bars of malleable cast-iron which can be drawn, and are drawn, into nails for horseshoes in an ordinary blacksmith's fire. More remarkable still, sheets may be rolled in an ordinary sheet mill from cast bars, which sheets possess all the qualities of charcoal iron. If our readers will realize for themselves the fact that a bit of cast-iron can be heated white hot and forged into a horse nail, or rolled into a sheet not nearly so thick as the paper on which this article is printed, they will be in a position to understand how suitable this material is for the construction of hydraulic press cylinders. As an example of what may be done with the material, we may give the dimensions of a hydraulic press cylinder cast for Messrs. Nasmyth, Wilson, & Co., by Messrs. McHaffie & Co., in 1869. The internal diameter of the cylinder is $10\frac{1}{2}$ in. ; the thickness of the sides $2\frac{1}{2}$ in. only; the total length 12 ft. $9\frac{3}{4}$ in. The thickness of the bottom $3\frac{3}{4}$ in. The working pressure will be over $2\frac{1}{2}$ tons on the square inch. It may be thought that cylinders of this length—and others have been cast by Messrs. McHaffie as much as 15 ft. long in the rough—will warp in the annealing. This supposition is perfectly correct, they do twist and bend sometimes. When this takes place they are straightened by the aid of a press just as though they were made of wrought-iron ; and we mention this fact because it tends to demonstrate the characteristics of the metal. As another instance of what may be done in malleable cast-iron, we may cite a press now being cast by Messrs. McHaffie for the Government. It is intended to bend armor plates. The

stroke is very short, but the diameter is not less than 2 ft. 5 in., and although the sides are but $5\frac{1}{4}$ in. thick they will be exposed to a strain of 4 tons on the square inch. The walls have been mape rather thinner than usual, in order to get the largest possible ram into the frame of the machine. By Molesworth's formula, if cast-iron were used, the sides of the cylinder must have been at least 18.75 in. thick ; but as it is well known that beyond a certain point no increase of thickness adds to the strength of a cylinder exposed to a bursting pressure, it is very doubtful if a cast-iron cylinder 2 ft. 5 in. diameter could be got to stand at all. The ram will have a diameter of about 2 ft. 4 in., and will exert a total strain on the plate to be bent of 2,463 tons, less the friction of the leather packing.

We shall not attempt to define what malleable cast-iron is. In grain it resembles steel, and he would be a rash man who attempted to assert that it was not steel. It is excessively close in texture, and in practice is found practically water-tight. Messrs. McHaffie have carried the manufacture of malleable cast iron to such perfection that, by altering the details of the process, they can totally alter the characteristics of the metal, producing either an excessively rigid, or an excessively soft and malleable material, the value ranging between £7 and £40 per ton. We regard the process as nothing less than a particular method of producing wrought-iron and steel in large and tolerably homogeneous masses. The cost of a malleable cast-iron cylinder is a little less than that of a pot steel cylinder of the same dimensions.

THE LAWS OF THE DEFLECTION OF BEAMS EXPOSED TO A TRANSVERSE STRAIN, TESTED BY EXPERIMENT.*

By Prof. W. A. NORTON, of New Haven, Conn.

I propose, on the present occasion, to communicate the principal results of a series of experiments made with an apparatus which I devised for the purpose of testing the theoretical laws of the deflection of beams exposed to a transverse strain.

[The apparatus was described in detail with the aid of several large diagrams. The following description will suffice to give an accurate idea of its essential features.]

It may be regarded as consisting of three different portions, viz. : (1) that which supports the stick to be experimented on ; (2) that which applies and measures the strain; (3) that which measures the deflection produced. The supporting apparatus consistsof 2 skeleton iron tables, each which is a rectangular wrought-iron frame $2\frac{3}{4}$ ft. long by 2 ft. broad, resting at the 4 corners upon cast-iron legs $2\frac{1}{2}$ ft. high. The longitudinal bars of this frame are 1 in. broad by 2 in. deep. These tables are placed lengthwise on the same line, say a north and south line, and 1 ft. $4\frac{1}{2}$ in. apart. Each of them supports a transverse sliding frame composed of 2 wrought-iron bars 1 in. by 2 in., placed 4 in. apart, and formed at the ends into 2 sliding saddle-pieces that rest upon the logitudinal bars of the table-frame. These sliding frames can be set at any distance apart, from 2 ft. to 6 ft. Upon each of them rests an iron plate $\frac{5}{8}$ths of an in. thick, and fitted by grooves to the 2 iron bars, so as to be movable in the direction of their length, or crosswise, to the lengths of the tables. Upon these plates rest 2 cast-iron supports, each consisting of an upright pillar, $1\frac{1}{8}$ in. square in cross section and 12 in. high, connected at the bottom with a plate that is supported by 4 levelling screws upon the sliding plates just described, and at the top with a plate 5 in. long (crosswise to the table-frames), $2\frac{1}{8}$ in. broad and $\frac{5}{8}$ths of an in. thick. The nearer edges of the top plates of these upright supports are bevelled off, so as to bring them immediately over the pillars. The stick experimented on rests immediately on these iron plates, and its effective length is the distance between their nearer edges.

The mechanical contrivance for applying the strain to the stick, like the supporting apparatus just described, is wholly

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*From the Proceedings of the American Association for the Advancement of Science. Eighteenth Meeting.

made of iron, and consists of an upright screw, turning by means of female screws in. 2 horizontal plates fastened at their 4 corners to upright columns. These columns are firmly connected with an iron bed plate, which is placed between the table supports above described and securely fastened to the floor-joists by long screw-bolts. The screw-head is connected by intermediate pieces with an iron stirrup that rests crosswise upon the stick. There is a special arrangement, which cannot well be described here, by which these intermediate pieces are made to move in a truly vertical direction, and not partake, in any degree, of the revolving motion of the screw. One of the intermediate pieces referred to, is a Fairbank's spring dynamometer (essentially the same as Regnier's). The circular dial-plate reads from 1 lb. to 1,000 lbs. By means of the screw a power of 1,000 lbs. can be applied to the stick; but in the experiments the strain was in no instance carried higher than 500 lbs.

The apparatus for measuring the deflection produced, consists of a brass lever of 2 arms, each 5 in. long, one end of which is depressed by the middle of the bent stick, and the equal rise of the other is measured by a micrometer-screw. This micrometer-screw reads to one ten-thousandth of an inch. The lever is placed crosswise to the length of the stick, and opposite its middle. It passes through a vertical slot in the iron stirrup that rests upon the middle of the stick, and presses by a blunt steel knob against the under side, the farther end of the lever being made slightly heavier than the other, so as to secure a moderate pressure. The arrangement for supporting the lever consists of a wooden strip $6\frac{1}{2}$ ft. long, $2\frac{3}{8}$ in. deep, and $\frac{1}{2}$ in. thick, stiffened along the top by a strip of brass. This is secured to the pillars of the two upright supports, by clamping-pieces, which firmly hold it at a distance of 5 in. from the centres of the pillars and parallel to the length of the stick. Upon this supporting strip rests a sliding saddle-piece, having a small flat plate on the top, and adjustable by horizontal screws that pass through its vertical side plates and press against the vertical sides of the wooden strip. Upon the top plate of this saddle-piece rests, by means of four levelling screws, another small plate, upon which the knife-edge of the lever immediately rests. From the vertical side-plate of the saddle-piece that is farthest from the stick, extends a small horizontal bar, 6 in. long. This lies directly under the farther half of the lever. Near its farther end the micrometer-screw passes through it from below upward, and touches the under side of the lever, at a distance of 5 in. from the knife-edge support. The contact of its rounded point with the lever is observed with a microscope. The screw-head, adapted to the lower end of the screw, is 2 in. in diameter. Its outer vertical edge is silvered, and graduated to read to thousandths of an inch; but a small vertical wire fastened to the bar above it, past which the screw-head moves, subdivides the smallest space on the graduation, so as to make it possible to read to the one ten-thousandth of an inch. Since the knife-edge of the lever is at the same distance from the point of contact with the upper end of the micrometer-screw and from that with the middle of the under side of the stick, the micrometer readings are the linear deflections of the middle of the stick. It will be observed that the depressions of the knob of the lever under the middle of the stick, will be the actual deflections; since the support of the fulcrum of the lever is firmly connected with the upright supports of the stick, and will partake of any depression that they may experience from any settling of the apparatus under the action of the force that produces the deflection. It may be remarked here that it was ascertained, by an independent set of experiments, that the actual depression of the apparatus was very small; only from two to three-thousandths of an inch for every 100 lbs. of pressure.

The manner of conducting the experiments will be readily understood. The inner edges of the top surfaces of the upright supports upon which the stick is to rest, are set at a distance apart equal to the proposed effective length of the stick, either 2 ft., 4 ft., or 6 ft. These surfaces are carefully levelled and adjusted to the same horizontal plane. The lower plates of the upright supports are firmly clamped to the sliding frames on which they rest, by portable clamps. The stick is then put in its place, the iron stirrup placed crosswise upon its middle, and connected by a

sliding bolt and key with the upper end of the closed spring of the dynamometer. The apparatus for measuring the deflections is also levelled and adjusted. The screw is then slowly turned until the index of the dynamometer indicates 100 lbs., 200 lbs., or any other force of pressure it is proposed to apply, and the reading of the micrometer-screw indicates the linear deflection of the middle of the stick produced by the pressure applied.

The experiments were made upon white pine sticks of various lengths, fron 2 ft. to 6 ft., and various breadths and depths, from 1 in. to 4 in. The results are derived from the means of a large number of experiments. As an additional test the experiments were repeated upon a second set of sticks.

The received theoretical formula for the deflection of beams of a rectangular cross section of uniform dimensions, is

$$f = m\frac{Pl^3}{4\,Ebd^3}$$

in which m is a constant, P the power applied, E the modulus of elasticity, l the length, b the breadth, and d the depth of the stick. For the case of a beam resting freely on two supports and loaded in the middle, to which the experiments were entirely confined, this becomes

$$f = \frac{Pl^3}{4\,Ebd^3}.$$

If this formula be correct, then the following laws must be true.

(1.) The deflection is directly proportional to the pressure.

(2.) It is inversely proportional to the breadth.

(3.) It is inversely proportional to the cube of the depth.

(4.) It is directly proportional to the cube of the length.

We will now compare each of these laws with the experimental results obtained.

First Law. The deflection is directly proportional to the pressure. The following table contains a few of the results that serve to test this law. The first three columns give the lengths, breadths, and depths of the sticks, and the last column gives the differences between the deflections produced by the two pressures given in the column headed Difference of Pressures.

The deflections for the first 100 lbs. of pressure are not included, for the reason that there is more liability to error in observing the absolute deflection than in observing the increments of deflection produced by each 100 lbs. of augmented pressure, starting from a pressure of 100 lbs. The actual results for the first 100 lbs. are given, for comparison, at the bottom of the table.

TABLE I.

Sticks.			Diff. of Pressures, in Pounds.	Diff. of Deflections, in Inches.
Length.	Breadth.	Depth.		
2 feet.	4 inches.	2 inches.	100 to 200	0.0114
2 "	4 "	2 "	200 to 300	0.0102
2 "	4 "	2 "	300 to 400	0 0090
2 "	4 "	2 "	400 to 500	0.0090
4 feet.	2 inches.	3 inches.	100 to 200	0.0459
4 "	2 "	3 "	200 to 300	0 0460
2 feet.	3 inches.	2 inches.	100 to 200	0.0159
2 "	3 "	2 "	200 to 300	0.0135
2 "	3 "	2 "	300 to 400	0.0127
2 feet.	2 inches.	3 inches.	100 to 200	0.0083
2 "	2 "	3 "	200 to 300	0.0084
2 "	2 "	3 "	300 to 400	0.0080
2 feet.	4 inches.	2 inches.	0 to 100	0.0119
4 "	2 "	3 "	0 to 100	0.0477
2 "	3 "	2 "	0 to 100	0.0164
2 "	2 "	3 "	0 to 100	0.0092

The following table gives the deflections f for 100 lbs., 200 lbs., 300 lbs., etc., pressure:

TABLE II.

Sticks. Length.	Breadth.	Depth.	Pressures, in Pounds.	Deflections, in Inches.
2 feet.	4 inches.	2 inches.	100	0.0119
2 "	4 "	2 "	200	0.0233
2 "	4 "	2 "	300	0.0335
2 "	4 "	2 "	400	0.0426
2 "	4 "	2 "	500	0.0516
4 feet.	2 inches.	3 inches.	100	0.0477
4 "	2 "	3 "	200	0.0936
4 "	2 "	3 "	300	0.1396
2 feet.	3 inches.	2 inches.	100	0.0164
2 "	3 "	2 "	200	0 0323
2 "	3 "	2 "	300	0.0458
2 "	3 "	2 "	400	0.0585
2 feet.	2 inches.	3 inches.	100	0.0092
2 "	2 "	3 "	200	0.0181
2 "	2 "	3 "	300	0.0264
2 "	2 "	3 "	400	0.0344

It appears from the results given in Tables I. and II., that the deflection is approximately proportional to the pressure ; but, strictly speaking, increases according to a less rapid law. The probable explanation of this discrepancy between theory and fact, is, that as the force of pressure increases, the neutral axis of the cross section of the stick shifts its position, and its distance from the centre of gravity of the cross section augments as the pressure becomes greater. From this cause the moment of the resistance to flexure increases indirectly with the pressure, at the same time that it increases directly from the augmented strains of the fibres. The increased moment of resistance to flexure resulting from this shifting of the neutral axis, should be attended with a diminished increment of deflection for the same increment of pressure.

Second Law.—The deflection is inversely proportional to the breadth. Table III. will serve to test this.

TABLE III.

Sticks. Length.	Breadth.	Depth.	Obs. Deflection for 100 Lbs., in Inches.	Cal. Deflection for 100 Lbs., in Inches.	Difference, in Inches.	Ratios of Error.
2 feet.	1 inch.	2 inches.	0.0423	0.0423	....	..
2 "	2 "	2 "	0.0195	0.0211	+0.0016	1-12
2 "	3 "	2 "	0.0147	0.0141	−0.0006	1-24
2 "	4 "	2 "	0.0106	0.0106	0.0000	....
4 feet.	1 "	2 "	0.2858	0.2858	....	....
4 "	2 "	2 "	0.1200	0 1429	+0.0229	1-5
4 "	3 "	2 "	0.0983	0.0952	−0 0031	1-32
4 "	4 "	2 "	0.0624	0.0714	+0.0090	1-7

The numbers in the column of calculated deflections are obtained by assuming the observed deflection for the smallest breadth (1 in.), and computing the deflection for the other breadths on the supposition that it is inversely proportional to the breadth. The last column gives the ratios of the differences between the observed and calculated deflections, given in the preceding column, to the observed deflections. The observed deflections answer to an increase of pressure from 100 lbs. to 200 lbs., or 200 lbs. to 300 lbs. It will be seen that the errors are some plus and others minus, and that the ratios of error are small fractions. They are, how-

ever, too great to be attributed entirely to errors of observation ; but not greater than may reasonably be ascribed to differences in the moduli of elasticity of the different sticks, and to the greater shifting of the neutral axis in the case of the sticks most strained, in connection with possible errors of observation.

Third Law.—The deflection is inversely proportional to the cube of the depth.

It soon became evident, in the course of the experiments, that this law could not be regarded as even approximately true, except in the cases of sticks, or beams, whose length bore a high proportion to their depth. The following comparisons of observed with calculated deflections will show that it fails in the case of sticks two feet in length.

TABLE IV.

Sticks.			Ratios of BD^3.	Obs. Deflection, in Inches.	Cal. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.					
2 feet.	2 ins.	1 inch.	....	0.1414	....	....	....
2 "	1 "	2 "	1 to 4	0.0423	0.0353	−0.0070	1-6
2 "	3 "	2 "	....	0.0147	....	....	....
2 "	2 "	3 "	1 to $2\frac{1}{4}$	0.0084	0.0065	−0.0019	1-4.4

TABLE V.

Sticks.			Ratios of D^3.	Obs. Deflection, in Inches.	Cal. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.					
2 feet.	2 ins.	1 inch.	....	0.1414	....	....	....
2 "	2 "	2 "	1 to 8	0.0195	0.0177	−0.0018	1-11
2 "	2 "	3 "	1 to 27	0.0084	0.0052	−0.0032	1-2.6

The calculated are all less than the observed deflections. The same is true when sticks of greater length than 2 ft. are taken, but the errors are smaller in proportion as the length is greater. It appears, therefore, that the deflection decreases according to a less rapid law than the inverse cube of the depth.

Fourth Law.—The deflection is directly proportional to the cube of the length.

The experiments show that this law fails, as well as the third.

TABLE VI.

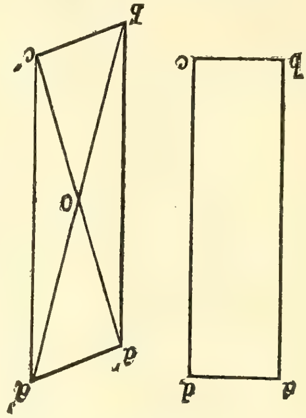
Sticks.			Ratios of l^3.	Obs. Deflection, in Inches.	Cal. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
Length.	Breadth.	Depth.					
2 feet.	2 ins.	2 ins.	....	0.0195	....	....	....
4 "	2 "	2 "	1 to 8	0.1200	0.1560	+0.0360	1-3.33
2 "	2 "	3 "	....	0.0084	....	....	....
4 "	2 "	3 "	1 to 8	0.0460	0.0672	+0.0212	1-2
2 "	3 "	2 "	....	0.0147	....	....	....
4 "	3 "	2 "	1 to 8	0.0983	0.1176	+0.0193	1-5
2 "	4 "	2 "	....	0.0106	...	....	....
4 "	4 "	2 "	1 to 8	0.0624	0.0848	+0.0224	1-2.8

We may conclude, from these results, that the deflection increases according to a less rapid law than the cube of the length of the stick. We have already seen that it decreases in a less rapid proportion than the inverse cube of the depth. It follows, therefore, that the true formula for the deflection probably contains at least one additional term, which varies less rapidly than as the cube

of the length directly and the cube of the depth inversely; or, in other words, contains l in the numerator, and d in the denominator, each raised to a lower power than the cube. Now, if we consider attentively the changes that must occur in the relative positions of the molecules within a stick or beam, when it is subjected to a cross strain, we may perceive that a cause of deflection exists which has hitherto been disregarded, or deemed too insignificant in its effects to be taken into account.

It is plain that when a stick or beam, of a uniform rectangular cross section, resting on two supports, is loaded at its middle, a vertical force equal to one-half the weight is transmitted to each support, by the slipping of each vertical section, or lamina, upon the next, until a vertical force of resistance is called into play equal to half the weight. As each section must transmit this same force to the next, the slipping of one section upon another must be the same from the middle to the end. The section at the middle will be directly depressed, from this cause, by an amount equal to the sum of all these displacements that occur between the middle and the end, or to any one displacement multiplied by the number of sections, or indefinitely thin laminæ, in this interval. This depression should, then, be directly proportional to the half-length, or length, of the stick. If we compare sticks of the same length but different cross sections, the number of fibres that are subjected to this cross strain, or the number of material points in each cross section whose vertical resistance will be called into operation by the slipping of this section upon the next, will be proportional to the area of the cross section, and hence the amount of the relative sliding displacement will be inversely proportional to this area. It will be seen, then, that the sinking or linear deflection of the middle of the beam, thus directly resulting from the slipping of contiguous vertical sections, may be represented by the expression $c\,\frac{Pl}{bd}$; in which P is the load, l the length, b the breadth, and d the depth of the beam, and C a constant that must be determined by experiment.

The theoretical deflection given by the formula which has been under discussion, is due to longitudinal strains on the fibres, indirectly resulting from the same slipping of contiguous sections. If ab and cd represent two vertical cross sections, indefinitely near to each other, of which ab



is nearest the middle of the beam, the transmission of the action of the half-weight will cause ab to slip relatively to cd until a vertical resisting force comes into operation equal to the half-weight; and the rectangle $abcd$ will take the form of the oblique parallelogram, $a'b'c'd'$. The diagonal ac will therefore be shortened, and bd lengthened. Accordingly a strain of compression will come into operation along $a'c'$, and a strain of extension along $b'd'$. The reactions to these strains will take place, along $a'c'$ from the middle o toward a', and from o toward c', and along $b'd'$ from b toward o, and from d' toward o. As a consequence, the points a' and d' will be urged by equal forces toward the left, or toward the middle of the beam, and the points $b'c'$, by the same forces, toward the right. The sum of the first two forces will then be a longitudinal strain of compression on the upper fibre, and the sum of the last two an equal strain of extension on the lower fibre. It will be observed that the strains here considered as confined to the upper and lower fibres, are actually distributed over all the fibres above and below the middle fibre of the beam.

The conclusions here arrived at with regard to one indefinitely small rectangle, $abcd$, will be equally true of any other that may be considered between the middle and end of the beam; and the same longitudinal strains will be developed by the slipping of contiguous sections in

each rectangle. The entire longitudinal strains on the fibres, at the middle, will then be the sum of the individual strains developed in all the rectangles of the half length of the beam. The ordinary equation of equilibrium of a beam may be readily made out from the present point of view; but we have now only to consider the matter of deflection. It will be seen that the movements, to the left and right, of the angular points of the parallelogram $a'b'c'd'$, that have been signalized, will be attended with a turning of the whole parallelogram from right to left around its centre o. The direct tendency to rotation will be the same for each parallelogram of the half length of the beam, but owing to the propagation of the longitudinal strains on the fibres developed at each parallelogram, from the end to the middle, the actual compressions and elongations will be greatest at the middle, and the actual rotation of the parallelogram there will be the greatest. The deflection consequent upon the elongations and compressions of the fibres, is the joint result of the rotary movements of all the parallelograms in the half length of the beam; and it is represented by the formula which has been under discussion.

It would seem, then, that the true theory of deflection conducts to the following formula, in the special case of a beam resting on two supports and loaded in the middle.

$$f = c\frac{Pl}{bd} + \frac{Pl^3}{4\,Ebd^3}$$

Let us now proceed to compare this formula with our experimental results. For this purpose we will determine the values of the two constants C and E for each individual stick, and compare the several values obtained. If the formula be correct, the different sticks all in precisely the same mechanical condition, and the experiments perfectly accurate, we should get the same values for these constants in the case of each stick. But the experiments are liable to more or less of error, and the sticks may differ materially from one another in their mechanical condition; and even where they do not, as the actual deflections experienced are so different with sticks of different dimensions, any changes in the values of the constants that may result from the shifting of the position of the neutral axis, under the operation of the strains, should differ more or less. The derived values of the constants may therefore differ among themselves, within certain limits, without leading us to conclude that the formula is probably at fault.

TABLE VII.

Sticks.			Difference of Extreme Pressures.		Difference of Intermediate Pressures.	
Set No. 1.						
l.	*b.*	*d.*	*E.*	*C.*	*E.*	*C.*
Feet.	Inches.	Inches.	Lbs.		Lbs.	
2, or 4	2	1	1,359,500	0.0000108	1,308,430	0.0000082
2	2, or 3	3, or 2	1,566,809	0.0000100	1,579,960	0.0000095
4	2, or 3	3, or 2	1,584,820	0.0000087	1,560,800	0.0000078
2, or 4	4	2	1,552,000	0.0000140	1,501,200	0.0000127
2, or 4	2	2	1,481,800	0.0000108	1,423,600	0.0000084
Means			1,508,986	0.0000108	1,474,798	0.0000093
Set No. 2.						
Feet	Inches.	Inches.				
2, or 4	3	2	1,277,729	0.0000084	1,254.000	0.0000080
2, or 4	3	3	1.295.984	0.0000089	1,315.000	0.0000088
2, or 4	4	2	1,558,900	0.0000110	1,542.860	0.0000107
2, or 4	2	2	1,561.822	0.0000084	1,600.000	0.0000100
Means			1,423,609	0.0000092	1,427,965	0.0000094

The above table contains the values of C and E, calculated from the deflections due to 100 lbs., for two sets of sticks of the same dimensions. They were all over 4 ft. in actual length, but in the experiments the effective lengths taken were either 2 ft. or 4 ft. The values of E and C were obtained, in some instances, by

taking the deflections for the same breadth and depth, but different lengths (either 2 ft. or 4 ft.), and in other instances by taking the deflections for the same length, but different breadths and depths. The results of two sets of calculations are given in the table. In the one the deflections answering to the least and greatest strains are taken, and the deflection due to 100 lbs. computed from the difference of these by simple proportion; in the other the same is obtained by taking the deflections answering to strains, or pressures, intermediate between the extreme strains.

The general formula applicable to white pine sticks of the general quality used in these experiments, will be obtained by taking the mean of the several values of E and C given in the above table. To test the theoretical formula we have obtained, we will take the mean values of E and C, for the second set of sticks, given at the bottom of the fourth and fifth columns, viz.: E=1,427,965 lbs., and c=0.0000094. We thus have

$$f = 0.0000094\,\frac{Pl}{bd} + \frac{Pl^3}{5{,}711{,}860 \times bd^3}$$

or, taking $P = 100$ lbs.,

$$f = 0.00094\,\frac{l}{bd} + \frac{l^3}{57{,}118.6 \times bd^3}$$

The following table contains the values of f calculated by this formula, and the results of a comparison of the calculated values with the deflections observed.

TABLE VIII.

Sticks.			Cal. Values of f, in Inches.	Obs. Deflection, in Inches.	Difference, in Inches.	Ratios of Error.
l.	b.	d.				
4 feet.	3 ins.	2 ins.	0.0882	0.0983	−0.0101	1-9.7
2 "	3 "	2 "	0.0140	0.0147	−0.0007	1-21
4 "	2 "	3 "	0.0434	0.0460	−0.0026	1-18
2 "	2 "	3 "	0.0082	0.0084	−0.0002	1-42
4 "	4 "	2 "	0.0661	0.0624	+0.0037	1-17
2 "	4 "	2 "	0.0104	0.0090	+0.0014	1-6.4
4 "	2 "	2 "	0.1323	0.1200	+0.0123	1-9.8
2 "	2 "	2 "	0.0208	0.0195	+0.0013	1-15

The comparative accuracy of the old and new formulas, will be seen on comparing the ratios of error in Tables IV., V., and VI., and Table VIII. It should be added that the results given in Table IV. are from calculations made in each instance on sticks which are identically the same, whereas those in Table VIII. are affected with the errors resulting from the fact that the values of E and C are the mean values obtained from a number of different sticks, which may differ more or less in their mechanical condition. If we take the average values of these constants given in the table for the stick 3 in. by 2 in. in cross section, and obtained by taking the deflections answering to the lengths, 2 ft. and 4 ft., the formula thus obtained gives, for these transverse dimensions and the lengths, 2 ft. and 4 ft., respectively, four results, the ratios of error of which lie between $\frac{1}{1500}$ and $\frac{1}{120}$.

TABLE IX.

Sticks.			First Term.	Second Term.	Ratio.	Sum.
l.	b.	d.				
			In.	In.		In.
4 feet.	3 ins.	2 ins.	0.00692	0.08952	1-12	0.0964
4 "	2 "	3 "	0 00692	0.03979	1-5.7	0.0467
4 "	4 "	2 "	0 00658	0.0554	1-8	0.0620
4 "	2 "	2 "	0.01000	0.1106	1-11	0.1206
4 "	1 "	2 "	0.01776	0.2681	1-15	0.2858
2 "	3 "	2 "	0.00346	0.01119	1-3.2	0.0146
2 "	2 "	3 "	0.00346	0.00497	1-1.4	0.0084
2 "	4 "	2 "	0.00328	0.00693	1-2	0.0102
2 "	2 "	2 "	0.00500	0.01383	1-2.8	0.0188
2 "	2 "	1 "	0.00990	0.13150	1-13	0.1414
2 "	1 "	2 "	0.00990	0.03301	1-3.3	0.0429

Let us compare the values of the first and second terms of the formula. This is done in Table IX. The values of E and C taken in the formula, are the individual values for each stick given in the second and third columns of Table VII.

It will be observed that the value of the first term is in general comparatively larger for the length of two feet, than for that of four feet; and in two instances is as large as one-half the second term.

If now we divide the first term by the second, we obtain as the general expression of their ratio,

$$4\,E\,C\frac{d^2}{l^2};$$

from which we see that it is proportional to $\left(\frac{d}{l}\right)^2$. When

$$\frac{l}{d} = \sqrt{4\,E\,C},\ 4\,E\,C\frac{d^2}{l^2}$$

becomes equal to unity, and the first term equal to the second. When $\frac{l}{d}$ has a less value than this, the first term is greater than the second. Taking the mean values of E and C, given in the last two columns of Table VII., for the first set of sticks, we have

$$\sqrt{4\,E\,C} = 7.41.$$

The mean values given in the same columns for the second set of sticks, give

$$\sqrt{4\,E\,C} = 7.33.$$

If, therefore, the length of a white pine stick be less than about seven and one-third times the depth, the deflection from the cause heretofore neglected becomes greater than from the cause to which the whole deflection has hitherto been ascribed. When the length and depth are equal, it is nearly fifty-five times greater; from which it appears that in this case the deflection directly due to the slipping of contiguous vertical laminæ, so greatly preponderates over that indirectly resulting from the same by reason of the longitudinal strains communicated to the fibres, that the latter is comparatively inappreciable.

It will be seen, from the general expression for the ratio of the two terms, above obtained, that the formula for the deflection may take the following form:

$$f = \frac{Pl^3}{4\,Ebd^3}\left(4\,EC\frac{d^2}{l^2} + 1\right).$$

I have made, with the same apparatus, a series of experiments on the degree of set, or residual deflection, communicated to sticks by varied strains, and under various circumstances, and obtained interesting and valuable results. The discussion of these experiments is reserved for another occasion.

ECONOMICAL STEAM ENGINES.

From "The Engineer."

The compound engine has been so long know to engineers that it is certain nothing remains to be learned by properly qualified persons, as to the conditions under which it may be most successfully employed, or the results that may be expected from it. To many so-called mechanical engineers, however, it is beyond doubt that the compound engine is, to all intents and purposes, a novel contrivance; and we are not surprised to find numerous firms just now embarking on its construction, or adopting it in their mills or in their steamships, with astonishing zest and relish; but those to whom the history of the steam-engine is familiar know well that just such a passion for compounding engines, as that which is now apparent in a few districts existed many years ago, and died a natural death. We have no intention of deprecating the use of compound engines, but we think it well to point out to employers of steam power, that the object they seek to attain by using them, can under the circumstances which usually obtain, be easily secured in a far more simple way; while we add that the use of the compound engine is only advisable under circumstances which do not now obtain at all, except in very rare cases.

It is, no doubt, very desirable that as little coal as possible shall be burned in obtaining a given amount of power, always providing that the use of a very small quantity of coal be not attended by a very large increase in the expenditure on other items, such as repairs, tallow, grease, brass, loss of time due to the engine standing idle, etc. We have dwelt

on these points so fully in two articles on economical steam-engines, which have preceded that which we are now writing, that it is unnecessary to refer to them more fully. We shall assume that the reader fully understands that the relative economy of different forms or systems of steam machinery must be estimated, not by the cost of coal alone, but by the entire cost of steam power as shown by each year's returns, and proceed to explain under what circumstances manufacturers are justified in adopting compound engines.

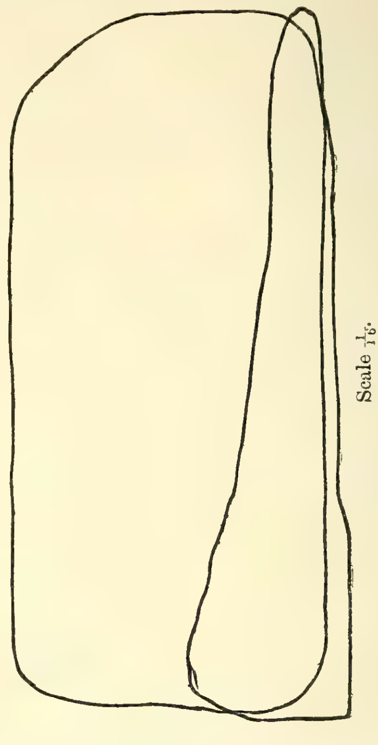
In the first place, then, the compound engine should never be used unless steam of very great pressure indeed is employed. To the use of steam as much as 500 lbs. per square inch we see no objection whatever, provided everything is made to suit. But it must be understood that a power-producing machine of this kind bears precisely the same relation to the ordinary commercial steam-engine, that one of Arnold's or Frodsham's chronometers bears to a good sound workman's watch. From beginning to end, in design, in construction, and in dimensions, it sets popular preconceived notions of the steam-engine at defiance. It is necessarily expensive to begin with, but if made in the proper way by a man who understands what he is about, it may continue perfectly efficient for many years, without any very great outlay on repairs. Such an engine as we speak of may be seen running now in Mr. Perkins' workshops, near King's Cross. The load on the safety-valve is 600 lbs. on the sq. in., and the total admission of steam is for 3 in. of the stroke of a 6 in. piston, the length of the crank being 6 in. There are in all three cylinders, and this engine has been known to indicate 100-horse power with this admission, the vacuum being 25 in. We shall enter into no details of the construction of this engine now; we propose to supply them to our readers in due course. We only refer to the engine at all here, because it affords an apt practical illustration of the conditions under which compounding is advisable, and of the difference between ordinary so-called high-pressure engines, and engines in which high pressure and enormous measures of expansion are used as they ought to be used.

We hold that the great mistake of the day lies in the use of steam, which is neither low nor high pressure, which, while entailing nearly every possible difficulty with which the engineer can have to contend, gives no collateral advantage over engines working with steam of much lower pressure. We believe that the logic of facts will bear us out when we make the somewhat startling assertion that nothing is to be gained in ordinary land practice by using a higher pressure than 100 lbs., or a greater measure of expansion than 7 or 8 times, until we employ a radically different type of engine and boiler, and resort to pressures of 250 lbs. to 500 lbs. on the sq. in., and measures of expansion of from 14 to 30 times. Over and over again have engines been "compounded" and "McNaughted," and fitted with all manner of strange and fantastical valve gear, without securing one atom of real economy. The McNaught or compound cylinders have been taken out again or discarded, as in the case of the Mooltan, one of the Peninsular and Oriental Company's mail steamers, which was fitted with double-cylinder compound engines. On one voyage a small cylinder was disabled, and steam was worked for the remainder of the run through the large cylinder in the ordinary way. On examining the coal account it was found that this was the most economical run the ship had ever made, though very far from being the slowest. The boiler pressure was but 25 lbs. above the atmosphere. "Compound engines for such pressures are simply gross absurdities," cries the intelligent critic; but, let us ask, where is the line to be drawn? We say at 40 lbs., or thereabouts, at sea, and at 100 lbs., or thereabouts, for stationary engines. After that let us begin compounding by all means; but we equally maintain that the limit of economical working is reached in ordinary engines at 100 lbs., and that the next step must be the adoption of a totally different form of generator and engine from anything now in general use, and a jump to pressures of 250 lbs. to 500 lbs. on the sq. in.

It is well to avoid the risk of being misunderstood on this point, and we therefore explain why it is that we have made the preceding statement. The reason is this: We do not think it to be good practice to use steam of more than

100 lbs. pressure in large simple engines; that is to say, in engines running at moderate speeds, and indicating 300 or 400-horse power, with high measures of expansion. When this point is reached the balance of advantage will probably lie with the compound engine, if thoroughly well made, nothwithstanding its complexity and its costliness; but this very complexity and costliness will usually suffice to render the economy gained by the resort to an additional 20 lbs. or 30 lbs. pressure absolutely nothing; so that a simple engine working 100 lbs. steam may be quite as economical as a compound engine working at a higher pressure and measure of expansion. But the moment an engine is compounded we enter, so to speak, a different sphere of conditions; and the prudent engineer, having first considered well whether he will or will not compound, and having decided that he will, should at once make up his mind to take advantage of all that compounding can give him, and consequently jump, at one spring, to very large measures of expansion and very high pressure, from which alone he can expect to receive an adequate return for the trouble and cost entailed by compounding.

Furthermore, it will be well to explain here why we limit the maximum of economical pressure at sea to 40 lbs., ordinary engines being used. The reason is that marine engines are exposed to rough usage in the way of shocks and strains, of which land engines, if we except those used in iron-works, know nothing. A marine engine fit for 40 lbs. at sea should be quite safe with 100 lbs. on land. As regards land engines, we are quite at a loss to understand why any necessity whatever should exist for the use of a second or compound cylinder if pressures not greater than 100 lbs., or measures of expansion not greater than 10 times, are employed. Let the single-cylinder engine have just the same weight of material employed in its construction, and that of its appurtenances, as is divided over two cylinders, etc., in the compound engine, and there will be little fear of a break down. It will be said that the motion of a single engine will be very unequal as compared with that of a compound engine. Not a bit of it! It is well known that no work that can be thrown on an engine is more irregular than that of rolling wide and long thin sheets — "doubles" or "lattens." It is, in the second place, evident that whether the application of power in the case of a constant load is irregular, or the power being constant



the load is irregular, the effect on the speed of the engine is the same. Now, we have stood beside an engine with a 32 in. cylinder, 5 ft. stroke, making 40 revolutions per minute, rolling sheets, and in the engine-house it was impossible to know whether a sheet was going through the rolls or not, except by seeing that the expansion cam was shifted from one grade to the next for a moment by a good governor. The load was increased for about five seconds, while the sheet was passing through, to an amount which may be estimated from the annexed diagram, which we recently took, not from this, but from a nearly similar engine. The small diagram shows the load when the mill is empty, that is to say, when the sheet is not between the rolls. The large diagram, the work done while the sheet is passing through. It will be understood, however, that the average diagram usually taken while a sheet is being rolled, will

be neither as high as the one nor as low as the other, for sufficiently obvious reasons. Now, why was it that the speed of the engine was so little affected? The governors were good, but of the common type; they were not Porter's, nor were they parabolic. The regularity of motion was due to the fact that on the engine shaft was hung a fly-wheel 28 ft. in diameter, and weighing not less than 60 tons. Fancy any ordinary cotton-spinning factory or flour mill with a 60-ton fly-wheel, on a 32 in. cylinder engine too! The engineer who proposed to put down such a wheel would be laughed at, yet in nine cases out of ten the use of a properly proportioned fly-wheel would render the compounding of engines totally unnecessary. A fly-wheel costs, say, to begin with, £6 10s. per ton if of a large size, and when once up it never costs another sixpence. The cost of a compound engine, as compared with a single engine, will be much more, in the first place, than the difference in price due to the difference in weight of a heavy fly and the light fly, and the extra cylinder will cost as much for its maintenance, or very nearly as much as a second engine, unless the workmanship is perfectly unexceptionable.

From all this we come to the conclusion that for pressures of about 100 lbs., and a ten-fold expansion, it is better to employ a heavy fly-wheel than a second cylinder, to insure regularity of motion.

The next difficulty lies in the fear of mischief being wrought by the shock of high steam on a large piston. There are two ways out of this labyrinth. The first is, to make the engine sufficiently strong; to which the answer is, that it costs too much; to which we reply that it will not cost as much as a second cylinder, etc. The other way is; don't use a large piston; instead, have a high piston speed; to which the answer is; that high piston speed engines are not durable, but knock themselves to bits; to which we reply, that the knocking to bits is due, not to the high piston speed, but to the very rapid change in the direction of the motion of the moving parts. Instead of big pistons moving slowly, or little pistons driving cranks making a fabulous number of revolutions per minute, let us employ engines with small pistons, a moderate number of revolutions per minute, and long strokes. The only things to be taxed by this arrangement are the crank and its shaft; and in these days of steam hammers and heavy forgings, there is no difficulty whatever in making crank and shaft perfectly secure. American engineers have much, perhaps, to learn from us, but we have to learn from them how to combine high piston speed with slow reciprocation. Let us cite as cases in point the steamboats Vanderbilt, with a 65 in. cylinder and 12 ft. stroke, making $22\frac{1}{2}$ revolutions per minute; the City of Buffalo, 76 in. cylinder, 12 ft. stroke, $19\frac{1}{2}$ revolutions per minute; the Golden City, Pacific mail steamer, 105 in. cylinder, 12 ft. stroke, $17\frac{1}{2}$ revolutions; the Metropolis, with a similar engine as regards dimensions, has made 20 revolutions; the engines of the New World, a paddle steamer 420 ft. long, on the Hudson, has made 20 revolutions per minute, stroke 15 ft., 76 in. cylinder; while the Richard Stockton, 50 in cylinder, 10 ft. stroke, made 30 to 32 revolutions. All these are overhead beam engines, the worst possible form of engine for high piston speeds; but here we have comparatively small pistons developing an enormous power, due to the great speed at which they run, although the number of revolutions is very small.

By the use, therefore, of small pistons, long strokes, and of heavy fly-wheels, steam of 100 lbs. may be expanded comfortably to ten times in a single cylinder; that is to say, there will be neither undue strain nor inconvenient irregularity of motion, nor any liability to break down or get hot bearings, due to too great a rapidity of reciprocation. Whether any advantage is likely to accrue from expanding 100 lbs. of steam more than six or seven times, we must reserve for consideration in another article.

In the six years of 1862-67 1,268 persons were killed upon the railways of the United Kingdom, and 4,426 persons were injured; among them were 112 passengers killed and 3,897 injured without any fault of their own, and 97 passengers killed and 29 injured owing to their own misconduct or want of caution, or at least attributed to this cause by the railway companies. In those six years the railway companies paid £1,460,568 as compensation for personal injuries done upon the railroads.

THE RESISTANCE OF PRISMATIC SECTIONS.

Translated from "Expose de la Situation de La Mécaniqùe Appliquée."

Improvements in experimental methods have, during our epoch, kept pace with improvements in analytic methods. Formerly experiments were made upon pieces of small dimensions; and the constants which were determined were applied to the same materials, whether employed in the smallest or the greatest works. The old experimenters followed this method; Buffon with wood, Rondelet and Rennie with materials employed in masonry, Barlow and Tredgold with iron and steel, Vicat with mortars. They had in view generally the determination of four quantities: the specific gravity, which enters into the calculation of the proper loads; the coefficient of elasticity; the limit of elasticity, and the breaking weight. A fifth remained to be determined, that is, the limit of the load for actual construction consistent with durability. These experiments, repeated by a great number of observers, under the most diverse conditions, have thrown great light upon engineering art. The tables of Genieys, in the section on the resistance of materials, present an excellent resumé in a succinct form.

The problem of the reaction upon pieces at their supports which leads to particular cases, has been studied experimentally; and Rondelet, in his "Art de Batir," reviewing all the facts collected by his predecessors with reference to the compression of wood, has given a practical rule, which indicates the successive reductions to which the limit of load should be subjected, as the ratio of the length of the piece to its least transverse dimension is increased. It follows from this rule that a piece 24 times as long as the side of its square section upon which it stands, will sustain only half the pressure which it would if reduced to the form of a cube. This subject has been taken up and perfected by the English engineers, whose experiments we shall now notice.

Among these experiments the most numerous and remarkable are those of M. Hodgkinson; the results of which were published in 1846, and which were translated in 1855, by M. Pirel in "Les Annales des Ponts et Chaussées." The experiments of Hodgkinson were intended to determine with precision the extreme resistance of steel to traction, to flexion, and to transverse strains, and to deduce from the observed phenomena the best form to give to solids made of this material. The old observers, always pre-occupied with the use of formulas deduced from the theory of flexion, did not attach great importance to the phenomena attendant upon rupture, and the majority neglected to extend their experiments beyond the limit of elasticity where the formulas cease to be applicable. The observations of Hodgkinson sensibly enlarged the field of the old experiments.

About this time the extended use of metal in construction upon railroads, and especially the construction of the great iron bridges, Conway and Menai, were the occasion of new experiments, very numerous and interesting. The account of these observations, generally extended to the point of rupture, is contained in the monograms upon the construction of these great bridges of Stephenson.

All these results have led to more exact determinations of the specific constants relative to iron. They show that iron obeys the theoretic laws of transverse flexion for slight deformations; that the coefficient of elasticity is reduced in very large works; that the resistance of iron to crushing is generally less than the tensile resistance. The reverse is true of steel. Besides, the limit of elasticity of steel is greater for compression than for tension; while in wood and iron the limits are the same. The coefficient of elasticity for steel is not the same for compression as for extension—a singular anomaly, which makes rigorous calculation of flexion very difficult. MM. Collet-Meygret and Desplaces have deduced an interesting consequence from observations made on the Viaduc de Tarascon; it is, that in steel the sections do not show everywhere an equal elasticity, so that it is necessary to distinguish the shell from the portions near the surface, giving to each its special coefficient. The line of demarcation between the two regions seemed to be difficult to trace rigorously. Iron drawn into wire of a small diameter

presents analogous phenomena ; so that it has long been known that iron wires contain elements that resist extension—a property utilized in the construction of suspension bridges.

Hodgkinson has made a special study of the resistance of pieces under pressure at their abuttings; among these, upon steel columns. His empirical formulas give the breaking load of a hollow column in terms of its height, and its external and internal diameters. The load which a column can safely bear is fixed at a sixth of the breaking load given by the formula. He has shown by numerous experiments the influence of the shape of the base, whether flat or round ; and also the effect of renflement. He has substituted a formula for wood instead of that given by Rondelet, and shows that the load supported by oak varies nearly as the fourth power of the least dimension divided by the square of the length. M. Sove has substituted more convenient formulas for solid columns of steel or iron ; they lead without difficulty to the choice between iron and steel for a column of given dimensions.

The observation of the vibratory motion of elastic solids leads to the determination of the coefficients of elasticity. It is the only method applicable to their plates or to wires. To this class of researches belong the experiments of Wertheim, and those of M. Phillips upon the spiral réglant.

In a scientific point of view the experiments upon the resistance of materials have shown that the hypotheses assumed in the solution of the problem of the deflexion of beams cannot be regarded as absolutely true. It is almost impossible to determine the limit of elasticity. A metallic bar, once subjected to tension, does not return to precisely its original form when the tension ceases, and its elasticity has undergone a certain alteration. The limit of elasticity, as understood in practice, is that limit at which alteration becomes sensible by the coarse methods of experiment; but as these become more precise, it is seen that this limit gradually diminishes, and it would without doubt disappear if the processes were perfect. The limit of elasticity is certainly of great importance ; but one should not pretend to determine it with a precision that cannot be applied in a practical problem. Late experiments have shown the existence of certain lacunæ in the theory, without filling them. They have shown the great complexity of the problems without suggesting the means of getting rid of it ; so that the old theory of deflexion remains the only guide that can be confidently followed, while we wait for the perfect solution which is to come from future investigations.

BLAST FURNACE ECONOMY.

From "Engineering."

At the general meeting of the Institution of Mechanical Engineers, held on Thursday, 28th April, in the Lecture Theatre of the Midland Institute, Birmingham, John Ramsbottom, Esq., President, in the chair, after the Secretary (Mr. W. P. Marshall) had read the minutes of the previous meeting, and a number of new members had been elected, the adjourned discussion was resumed upon the paper read at the previous meeting, "On the Further Economy of Fuel in Blast Furnaces, derivable from the High Temperature of Blast obtained with Cowper's Improved Regenerative Stoves at Ormesby, and from Increased Capacity of Furnace," etc., by Mr. Charles Cochrane, of Dudley. The improved regenerative hot-blast stoves at the Ormesby Ironworks, Middlesbrough, are heated entirely by the waste gas taken off from the blast furnaces; and the heat developed by the combustion of the gas is stored up in the stoves by means of the "regenerator," consisting of a large mass of open-built fire-brick, through which the heated current is made to pass in a downward direction on its way to the chimney. The mass of fire-brick thus becomes heated up to a very high temperature at the top, the temperature gradually diminishing towards the bottom of the regenerator ; and the blast, being then caused to pass through the regenerator in the contrary direction, takes up the heat stored in the fire-brick, and becomes itself heated to the same high

temperature previous to entering the blast furnace. In the present stoves, which are of considerably larger dimensions than the original stoves on the regenerative plan at these works, the combustion chamber at the top of the stove has been increased in proportionate capacity, in order to insure, as far as possible, the complete combustion of the gas in the stove before entering the regenerator ; the area of all the passages has also been enlarged, and the fire-bricks in the regenerators are set wider apart. A recent improvement has been made in the construction of the regenerators, which avoids the necessity previously existing for the use of a purifier to separate the dust brought over with the gas from the blast furnace, for the purpose of preventing the passages in the regenerator from becoming gradually choked up by the accumulation of this dust. In the improved construction the successive courses of the fire-bricks are so arranged that the edges of the bricks in each alternate course project a short distance beyond the edges of those in the courses immediately above and below ; and the regenerator is thus made up of a collection of vertical flues, the internal surfaces of which are broken by a number of projecting ledges, whereby the interchange of heat between the mass of brickwork and the currents passing through it is very completely effected. At the same time a clear straight passage is left from top to bottom of each flue, large enough to admit of cleaning out the dust deposited upon the faces of the brickwork, either by the insertion of a brush or by the use of a jet of blast, without the necessity of removing any of the bricks for the purpose. In consequence of these improvements in the regenerative stoves, the blast heated by them is now maintained in regular working at the high temperature of more than 1,400 deg. Fahr.; and although the annual expenses for cost and maintenance of the regenerative stoves are about the same as those of the most improved cast-iron stoves heating the blast to about 1000 deg. Fahr., the economy of fuel in the blast furnace consequent upon the higher temperature of blast, is found, from the experience of actual working, to amount to as much as 4 cwt. of coke per ton of iron made. The amount of economy of fuel, however, that is due to equal increments of temperature in the blast, has been found by the experience of the temperatures already reached in practice to diminish rapidly as the temperature is raised; and it is therefore considered by the writer that the further saving of coke in the blast furnace for a still further increase in temperature of blast from 1,400 deg. to 1,700 deg. would be less than 1 cwt. per ton of iron. With regard to the capacity of blast furnaces as affecting the economy of fuel by diminishing the temperature of the escaping gas, the actual result now obtained at the Ormesby Ironworks, with a furnace of 20,000 cubic ft. capacity, is a consumption of 20 cwt. of coke per ton of iron, with the blast heated to upwards of 1,400 deg., and with calcined ironstone yielding 40 per cent. of iron; and assuming that the same reduction of temperature which has been effected in the waste heat escaping from the regenerative stoves by doubling their capacity would also be effected in the waste gas escaping from the blast furnace by doubling the capacity of the furnace, it would follow that by doubling the capacity of the present large furnaces of 20,000 cubic ft. the further economy of fuel consequent upon reduction of heat in the escaping gas would be about 2 cwt. of coke per ton of iron made. In reference to the effect of increased heat of blast upon the temperature of the escaping gas at the furnace top, the working of two similar furnaces of 20,000 cubic ft. capacity each, has shown that neither extra heat of blast nor extra driving has any prejudicial effect on the temperature of the escaping gas; and that the extra heat thrown into the furnace by the hotter blast is met by the extra duty to be performed in compensating for the diminished proportion of coke consumed per ton of iron made.

A description was then given of the Regenerative Hot-Blast Stoves employed at the Consett Ironworks, Durham, by Mr. Thomas Whitwell, of Thornaby, Stockton-on-Tees. These stoves are constructed with a series of transverse vertical walls of fire-brick with narrow spaces left between, forming the regenerator, in which openings are made alternately at the top and at the bottom of the successive walls for the passage of the current. The waste gas from the blast furnace being mixed with air and ignited in a combustion chamber at one side of the stove, the

heated current passes alternately upwards and downwards through the successive spaces left between the series of tranverse walls, depositing its heat in the brickwork, and reaching the chimney valves on the opposite side of the stove at a low temperature. The regenerator thus becomes highly heated on the side of the combustion chamber, but remains cool on the chimney side; and the blast being afterwards passed through it in the contrary direction, takes up the heat from the successive fire-brick walls, and becomes itself heated to the same high temperature previous to entering the blast furnace. Cleaning doors are provided in the roof of the stove, through which scrapers are inserted for scraping off the dust deposited upon the surface of the walls; and the dust scraped off is raked out through side doors at the bottom of the stove. By this means the gas dust is easily removed in a very short time, the cleaning being effected entirely from the outside, whilst the stove continues hot, without requiring to be cooled down at all for the purpose; and a small pair of these stoves at the Thornaby Ironworks have been at work for several years without requiring any cleansing of the gas prior to its use in the stoves. The saving of coke in the blast furnace, consequent upon the use of the blast supplied by these stoves at the temperature of 1,400 deg. Fahr., has been found at the Consett Ironworks, where several of the stoves have been a year at work, to amount to 5 cwt. of coke per ton of iron made, in comparison with the consumption required in a furnace supplied with blast at 850 deg. by cast-iron stoves; and the actual consumption with the blast at 1,400 deg. temperature is less than 18 cwt. of coke per ton of iron, in a furnace making 400 tons per week, and burdened with a mixture of Cleveland and hematite ironstone yielding 48 per cent. of iron.

PARKER'S STEAM AND AIR ENGINE.

From "The Engineer."

Two inventions now claiming public attention possess no small amount of interest for employers of steam-engines. The inventors of both propose to increase the power to be obtained from the combustion of a given weight of fuel by working air expanded by heat in conjunction with steam. The first of these inventions, in point of date, is Parker's steam and air engine; the second is Warsop's aero-steam engine. The general principles involved are, up to a certain point, the same in both motors; but the method of applying these principles in practice differ widely. We have not as yet had any opportunity of personally examining and testing a Warsop engine, and we are, therefore, unwilling to say anything about it. At some future day, when a test engine now being constructed by Messrs. Easton and Amos, for Mr. Warsop, is complete, we hope to say something more on the subject. For the present, we shall confine our attention to Mr. Parker's invention, which we tested practically for some hours on Tuesday last, with results which we shall now proceed to place before our readers; premising that in the Warsop engine air is forced by a suitable pump through a coil of pipes exposed to a high temperature, into the water contained in any boiler that may be employed —Cornish, marine, or locomotive—the air on entering being in all cases much hotter than the water. In Parker's engine, on the contrary, the air is forced directly into the steam pipe leading to the cylinders, and, therefore, cannot have a higher temperature than that of the steam with which it is in contact.

The engine which we examined stands in the yard of Messrs. Yarrow & Hedley, Isle of Dogs, and is driven by one of the small boilers used by the firm in propelling steam launches, for the construction of which they enjoy an excellent reputation. This boiler contains an internal fire-box, communicating with a smoke-box by 47 vertical tubes 8 in. long. The total heating surface is 22 square ft., of which 11 ft. are in the tubes. The engine is an old launch engine of an antiquated pattern, with 2 cylinders 5 in. diameter and 6 in. stroke, horizontal, with a fly-wheel exactly 14 ft. in circumference hung on the shaft between the 2 cranks. Two steam pipes place the boiler in communication with the cylinders; one leads directly to them

in the ordinary way, the other is fitted with Mr. Parker's apparatus, which we are about to describe. The effect of the arrangement is that the engine can be run either with steam only, or with steam and air. Mr. Parker's apparatus consists of a vertical steam pipe, A, in the accompanying rough sketch, and a vertical "air" pipe, as it is called for want of a better name, B. This last communicates with A by means of 4 small nozzles, D, of brass, each having an orifice of $\frac{1}{8}$ in. diameter. The nozzles are surrounded each by a small tube, pierced with holes, through which the air is drawn by the inductive action of the steam passing from B to A. We append an elevation and section, full size, of one nozzle. The construction is very peculiar, but we cannot stop now to explain why these peculiarities are present. A cock is fitted on the engine to regulate the pressure of steam and air in the pipe A, and another is fitted between the boiler and B to regulate the pressure in the latter. It will be understood that all the steam used in driving the engine must find its way through the nozzles, which are to all intents and purposes open to the atmosphere. The pipe A is 1 in. in diameter inside, and passes through a small coke fire C; this fire is, however, in no way essential to the utility of the apparatus. Our readers are now, we think, in a position to understand what follows.

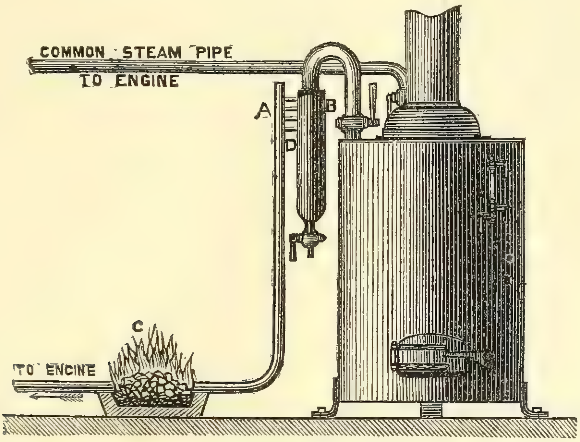
We carried out two trials on Tuesday. The first was intended to determine the quantity of coal used during a given amount of work done with steam only. The second was intended to decide the same point when air and steam were used together. In order that the principle might be fairly tested, the boiler, engine, and load were precisely the same in both trials. The fly-wheel was fitted with an ordinary belt-and-block brake, carrying a load of 30.5 lbs. The engine was fitted with a counter. Steam was first raised to 60 lbs. pressure. The fire was then drawn, only enough being left to light the fresh coal then supplied. The quantity of coal allowed for each trial was half a cwt. The engine was started, and run against the brake at as nearly as possible 90 revolutions per min. When all the coal was used, and the pressure began to fall, the speed of the engine was carefully noted, and as soon as it fell below 80 revolutions the engine was stopped, and the running time and number of revolutions noted; the water was left at the same height in the gauge as at the beginning of the experiment. Sufficient fuel was then put on the fire to raise the steam once more to 60 lbs. The fire was then drawn, and firing commenced with the second half cwt. of coal, and a run made with the new system in precisely the same way. As soon as the speed fell below 80 revolutions the engine was stopped, and the number of revolutions and the running time noted. We have arranged the results for convenience in the following table:

Steam Only.

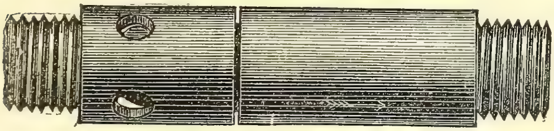
Started.	Stopped.	Running Time.	Total Number of Revolutions.	Average do.	Total work done, in foot-pounds.	Actual H. P.
h. m. 2.50	h. m. 3.45	h. m. 0.55	4,827	87.763	2,061,129	1.135
		Steam and Air.				
h. m. 4.3	h. m. 5.31	h. m. 1.28	8,071	91.715	3,446,317	1.186

It will be seen that we have here taken no account of the coke used in the little superheating fire C.; nor is it, we think, necessary that we should. The length of pipe in the fire was just 15 in.; the total superheating surface about 50 in. only. It was certainly not more efficient than the addition of 100 sq. in. of tube surface to the boiler; or, in other words, the addition of $\frac{1}{3168}$ to the heating surface of the boiler, an augmentation which bears an infinitesimal proportion to the total amount gained by the use of the induced air. Mr. Parker assures us, however, that from the use of the superheating surface an amount of economy results which

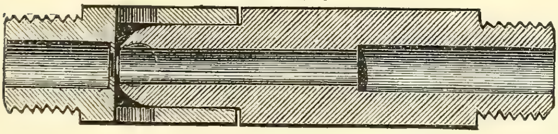
appears to us to be totally inconsistent with the smallness of the surface ; in no case can it account for the foregoing saving of 70 per cent. in fuel. The objection which will be urged by many engineers to the system is, that, although the results of its application are so satisfactory in the use of a very bad engine, they will not hold good of a better engine. What, it will be said, can be thought of an engine burning 56 lbs. of coal, or thereabouts, per horse per hour ? But it must not be forgotten that the fault lies as much with the boiler as the engine. Careful experiments made by Mr. Parker during the last 6 years show that, under the conditions, each $\frac{1}{8}$ in. jet will pass about 30 lbs. of steam per hour ; that is to say, for the 4 jets, 120 lbs. of steam. We did not measure the water used, but judging by this estimate of Mr. Parker's, and the number of buckets of water actually pumped into the boiler by hand during the trials, we are inclined to believe that the boiler does not evaporate much over 3 lbs. of water per pound of coal burned. But Mr. Parker's



EXTERNAL VIEW.



SECTION.



system has nothing whatever to do with the defects or merits of the boiler. If the boiler were better, the economy of fuel would be increased precisely in the same ratio. As regards the engine, it possessed precisely the same qualifications for using steam to advantage as it did for using steam and air combined. It is unnecessary here to go into an elaborate investigation of the reason why the use of air, as proposed by Mr. Parker, must be attended with advantage ; that is a subject which we must reserve for another article. Dealing with the thing for the moment in a purely practical way, we may point out that the engine is a meter, measuring more or less exactly the quantity of fluid passing through it per min. or per hour. If the source of supply is the boiler alone, then all the fluid passing through must be supplied by the boiler ; but if steam and air pass through together, as the cylinders will only pass a given quantity of the combined fluids in a given time, then the demands made on the boiler for steam will be reduced by just the amount of air

which takes the place of steam. In other words, if the engine working steam alone used 120 lbs. per hour, and, when using half steam and half air, still passed only 120 lbs. of the combined fluids, then, roughly speaking, it would only pass 60 lbs. of steam—as the weight of steam and of air is not the same, volume for volume; this statement requires correction, but, being used merely to illustrate a principle, it is sufficiently accurate. It may be urged that the steam does work in taking in the air, which is true ; but it is also true that, bating the friction in the nozzles, no work is done on the air which it is not placed in a position to return in the form of duty done on the air which is not placed in a position to return in the form of duty done on the pistons. By far the larger portion of the work done by the steam is expended in raising the temperature of the air ; but seeing that the specific heat of air is only about half that of steam, and that air expands 1-490th for each increment of 1 deg. Fahr. of heat, it is evident that the steam does this work at considerable advantage ; probably to far greater advantage than it can do any other work whatever on extraneous matter.

The working pressure of the steam *in the cylinders* was about 16 lbs. on the sq. in., both with and without the air jets. When steam alone was used it was impossible to maintain a pressure of 60 lbs. in the boiler with any larger opening of the stopcock regulator than that giving a speed of about 87 revolutions per min., which corresponded with a cylinder pressure of about 15 lbs. If the stopcock was opened further the pressure fell. The pressure of the induced current—in other words, that within A—was 15 lbs., while at the other end of the pipe next the engine it was 16 lbs. to 17 lbs., as shown by 2 gauges corresponding with each other. The true objection to the Parker system is that the engine pressure cannot be *economically* made to exceed about one-third of the boiler pressure. But, on the other hand, it is claimed for the system, and we think with justice, that the average pressure throughout the stroke will always be higher with any given amount of cut off than it practically is when steam alone is used. The reason why is sufficiently obvious. Steam is condensed and loses its pressure with frightful rapidity when in contact with a cold surface, whereas air under the same circumstances parts with its heat with extreme sluggishness as compared with steam. Thus the expansion curves of diagrams taken with steam and air combined passing through the engine are always much higher than when steam alone is used; from this it follows that a given area of piston is more effective with steam and air than with steam only. If, then, low pressures are to be used in non-condensing engines, we must do either of two things—use larger cylinders, or higher speed to obtain the same power. But then if we use high measures of expansion with steam alone we must have large cylinders ; and it is maintained for the Parker system that using a boiler pressure of 100 lbs., we can have an initial cylinder pressure of 35 lbs., which, cut off at half stroke, will give an average pressure of 29 lbs. or thereabouts ; while if steam alone be used of 100 lbs. pressure, it must be expanded some 7 or 8 times to prove equally economical, and with this measure of expansion the actual average pressure in practice will not exceed 30 lbs. or thereabouts. In confirmation of this theory, we may cite the case of an engine from which we have taken numerous diagrams; with a boiler pressure of 50 lbs., cut off at rather more than half stroke, the average pressure ought to be 42.3 lbs. per sq. in. It is actually, according to the diagrams, 22.9 lbs. ; and this is a well-made engine, working up to 110-horse power, with the cylinder and steam pipes carefully lagged, and the pressure in the valve chest within 3 lbs. of that in the boiler.

Of course, if this theory hold good, the great advantage of the Parker system would lie in the fact that expanding a mixture of air and steam onefold in a given cylinder, the consumption of fuel will be the same as though steam alone of the same initial pressure were expanded seven or eight fold. We should at one stroke thereby get rid of all the evils proper to irregular driving force. Precisely how far the theory which we have thus sketched may or may not correspond with the results of practical trials on a large scale we are unable, of course, to say ; but it is indisputable that we have obtained results from the Parker system more satisfactory than any we have ever

obtained, or known to be obtained under similar circumstances, from other improvements in the steam-engine, and it must not be forgotten that these results have been secured by the aid of one of the simplest and most inexpensive devices which it is possible to conceive; the entire cost of a Parker apparatus for an engine of moderate size probably not exceeding £10 or £15 sterling.

BRIDGE CONSTRUCTION.

By Col. W. E. Merrill, U. S. A.

There are some points in the review of my recent work* on "Truss Bridges," published in the "Journal of the Franklin Institute" for February, 1870, which I think demand reply, and as the reviewer has, in some points, misunderstood the object of my work, and my reason for going into certain elaborations, which I agree with him in considering unnecessary in practical construction, I am glad to be able to avail myself of the opportunity for restating my object and views.

My object was not in any way to deal with the details of making the parts of a bridge, which pertain rather to mechanical than to civil engineering, but simply to discuss the problem of *form*—to endeavor to ascertain, by calculation, *which* method of combining chords, posts and braces would give the best results—or, in other words, would necessitate the use of the least amount of iron to carry with a given degree of safety a given moving load. To do this it became necessary to take each well-known form of bridge and calculate the weight of each one of its parts with the utmost nicety, assuming for each one of the trusses examined the same permanent and rolling load, and the same general dimensions.

To do this, with justice to all, I was necessarily led into many refinements of calculation which in ordinary cases are entirely unnecessary; such as the "extra strains," and for some spans, the subdivision of the rolling load.

It is well known that when a long pillar is loaded with a weight acting through its axis, it breaks by flexure, under a strain much less than the crushing weight of its cross section. It commences to bend under a still smaller weight. The moment this begins it becomes, as it were, two pillars making a very obtuse angle with each other, held together by molecular cohesion. Every pound of additional weight gives necessarily a transverse component at the point of flexure, as well as a component through the lower half of the pillar, neutralized by its support. Manifestly, if we can hold the pillar in any manner at the point of flexure so as to neutralize this transverse component, and prevent it from acting on the pillar, we very greatly increase its capacity to withstand a strain through its axis. If this pillar were composed of a number of small pillars fastened together, no matter in what way, this tendency to flexure would still exist. But the top chord of a bridge, with the strains through its axis, presents an analogous case, with the additional unfavorable transverse action of its own weight. The chord, therefore, must naturally sag somewhat; and no matter how carefully the mechanical connections are made, as it is impossible to keep the segments in a strictly accurate line, there must be generated transverse strains at the joints of the series. If this were not the case, why is it necessary to have top lateral bracing? Parallelism of the trusses could be secured by connecting the end posts, were there not deflecting agencies to be guarded against at other points. Universal practice in construction recognizes the existence of these abnormal horizontal strains. It seems, therefore, an inevitable conclusion that the abnormal vertical strains should be recognized also. How to estimate for them is a different matter, and, after long and patient study and investigation, I could decide upon no better or simpler method than that given in the text.

Experience has shown that in the Bollman bridges it is absolutely necessary to introduce panel posts and ties which form no part of the weight-bearing system. The theory which I have adopted ac-

* "Iron Truss Bridges for Railroads," by Brevet Col. Wm. E. Merrill. Published by D. Van Nostrand.

counts for their use and necessity, and gives an approximate means of estimating their sizes. Knowing them to be essential in this bridge, I was necessarily led to examine into the need of something similar in other bridges. The calculations show that in most others these "extra strains" are, in the main, provided for by the ordinary posts and braces. But, as a matter of justice to all, I was compelled to take these strains into account wherever they added even a pound to the maximum direct strains on any principal member. Though I admit freely that in most cases such a discussion is an unnecessary refinement, I yet must insist that in a *comparison* as to economy in combination it is imperative to take everything into account that can effect the result. I thought that my opinions and reasons on this matter were all set forth with sufficient clearness in the work itself, but as the reviewer seems to have failed to appreciate my argument I hope that this explanation may be of service to him As to the size of top chord selected for computing these extra strains, I am aware that I exaggerated somewhat, but I considered it best to do so in order to provide fully for shocks and vibrations that cannot be brought down to exact calculation.

The "mathematical jugglery" referred to in the review is simply the necessary transposition of terms in Hodgkinson's formulæ in order to obtain, in the shortest time and simplest manner, the values of the *diameter*, which in bridge calculations is necessarily the unknown term. Hodgkinson's formulæ only show how to find the breaking weights of *given* pillars; but in bridges this breaking weight, which is the maximum strain increased by the factor of safety, is a *known* term, as is also the length. It is, therefore, an absolute necessity that the equations be solved with reference to d, the unknown term and quantity sought. In the case of short pillars the difficulty in obtaining d is still further increased by the use of his formulæ. It is true that when d is given and W is sought these formulæ are of easy application, but when the reverse is the case, d can only be obtained by a series of approximations, unless the equations are combined and a single equation deduced for the value of d. This simple and necessary work seems to have bewildered the reviewer, and, therefore, he contemptuously styles it "jugglery." This is certainly a strange term to use in a serious review of a professedly mathematical work.

The reason why I made use of the round-end formula in calculating compression strains is fully stated in the work. According to Hodgkinson the strength of a flat-end pillar, not immovably fixed, is about one-third of what it is when the ends are so secured that no motion whatever can take place. Posts and Top Chords in bridges, however accurately the connections are made, are subject to vibrations and small movements, and therefore are not proper cases for the use of the flat-end formula. It is a matter of choice whether we should use the flat-end formula, divided by three, or adopt the round-end one, which gives exactly the same result. Bearing in mind that my object was only to institute a comparison for the purpose of ascertaining the merits of the different combinations, it seemed immaterial which course I had better follow, and therefore I choose the one that seemed simplest—using the same formula in all cases.

I am quite willing to concede that "ordinary engineering calculations do not require astronomical accuracy," but the reviewer should have borne in mind that I was not making an ordinary engineering calculation, but a *comparison*, and therefore was compelled to take everything into account that could effect the result. I have used logarithms freely in order to insure accuracy, and because Hodgkinson's formulæ cannot be used without them; and I cannot believe that any good engineer can afford to neglect so great an assistance, or can find any difficulty in its use. At all events railroad engineers, who are daily using logarithmic sines and tangents, can hardly object to logarithms of numbers. I have been very careful in the tables to give both the actual numbers and the logarithms of all constants, in order to facilitate as much as possible the use of the formulæ.

The nomenclature of the trusses examined is but a small matter at best. It was necessary to name them for convenience of reference, and I used my best judgment in choosing the designations adopted. If I have, unintentionally, done injustice to any bridge builder I regret it; but as the

trusses themselves are carefully drawn in outline, those disliking the titles which I have chosen may give them such others as may seem to them more fitting.

I am aware that the Fink and Bollman bridges are better as deck than as through bridges, and I have so stated ; but as from necessity the great majority of railroad bridges are overgrade I did not deem it necessary to make a special discussion of undergrade bridges.

The only really important objection that the reviewer has advanced is that to my manner of treating the counter. But while he objects to my conclusions, and quietly states that there can be no question as to the true use and action of this member, he neither refers to the proofs which I have alleged in favor of my view, nor gives any himself. I am fully aware that many high authorities on bridge building are on his side, but the assumption that *all* are, and that there is but one opinion on the point involved, is gratuitous and inaccurate. The point is *not* a conceded one, and if it were, he should have been able to point out the error in the course of reasoning by which I apparently proved the contrary. I have endeavored to prove every step which I have taken, and also to express these proofs so clearly that no one could misapprehend my meaning. The natural inference is, that the reviewer could not successfully attack my demonstrations, or else that he examined the book so carelessly as not to have noticed them.

In reference to the use of cast-iron for compression, I have simply expressed my individual preference. The strongest reason for my choice of it in making the comparison as to economy in combination, arose simply from the fact that cast-iron compression members can more readily be calculated from formulæ than similar parts of wrought-iron. The latter depend for strength so much on mechanical skill and peculiarity of combination, that the only sure dependence on them comes from experiment. I doubt if a formula could be found that could give, with any reliability, the comparative strengths of the different posts and chords in use. Moreover, the object of the treatise was not to discover which bridge-building company had succeeded in getting the best posts and chords to sustain given strains, but to ascertain which would have the least strains to meet, and which, therefore, ought to be able, with a given amount of metal, to make the strongest bridge. The test of this point simply required perfect conditions of equality—and, it was believed, that such equality could best be secured by assuming cast-iron compressive members. The reviewer refers, occasionally, to Mr. Shale Smith's pamphlet, in terms of commendation. If he will examine it carefully, he will there find that Mr. Smith has spoken much more decidedly of cast-iron than I have.

The competition for the Quincy bridge is adduced as showing, from the builders themselves, a different estimate of weights from that which I have deduced. This is begging the question, as there is nothing to show that the three bridges had the same strength. The bidders may have overestimated or underestimated the strains which they were to provide for. The comparative statement is of no value at all unless it be shown conclusively from calculations made by the same engineer, that the three bridges were equally strong throughout. Comparing the bids with my own calculations for the same span, I can only conclude that Mr. Post would have built the strongest bridge.

Finally, I would like to add a few words about the object and purpose of my work. I do not claim it to be exactly correct, but simply that it is correctly reasoned to the best of my ability. Bridge-building, as a science, has improved greatly within the last few years, and it is to be presumed that it will continue to improve. Until it reaches perfection it is the bounden duty of all engineers to contribute what they can to clear up any dark points. By combining the studies and knowledge of many, some clearing up one obscure point and some another, though no one author may be right throughout, yet those that come after can gather up the scattered truths and build up a harmonious and correct system. Believing this, I have given my little work to the world, not as finally conclusive on the subject of truss bridges, but simply as my individual contribution. That it would meet with hostile criticism I expected, but I hardly looked for so *ex-parte* and thoroughly prejudiced a review as that which has called forth this reply. The best points in the work are quietly ignored and much ado is made about preface and bridge titles, things in them-

selves of little importance, and of no bearing on the general result. I gladly invite criticism, and hope that much good, to myself and others, may arise from the full discussion of the points at issue; but I hope that the next reviewer may come to his task without a mind as evidently made up in advance, and so determined to see nothing good in the work. I have prepared this answer to the reviewer more because of the influence and character of the journal in which his critique appears, than on account of anything in the article itself.

THE TORSION OF CRANK SHAFTS.

From "The Mechanics' Magazine."

In any ordinary type of steam-engine without a rocking shaft, the only portion of its mechanism subjected to torsional strains is the crank shaft, and it may not be out of place if we consider their nature and magnitude. Some authors would appear to consider them as being alike uniform, whether the steam be worked to a high degree of expansion or not. Such a supposition is, however, an erroneous one, as we can soon show. Evidently the torsion on the shaft is proportionate to the speed of the piston—we will assume but one for the sake of simplicity. Let us first take the crank at the dead centre; it is clear that whatever the pressure on the piston now, there is no twisting strain whatever on the shaft, because the piston is absolutely motionless, and without motion or the tendency to move if at liberty, there can be no strain. We may now move the piston to the point it would occupy with the crank at right angles to the axis of the cylinder; here the piston, if the engine were running, would have its maximum speed, and consequently, were it not for the loss due to the obliquity of the connecting rod, the torsion of the shaft would likewise be greatest, if the steam were not cut off before the half stroke; or, to bring the question to analysis, the calculation with the crank at the dead centre, and assuming a 6 in. cylinder and 12 in. stroke, with 50 lbs. steam, would give a pull on the piston rod of, say for simplicity, $28\frac{1}{4}$ square inches by 50 or 1,412.5 lbs., but there would be no torsion on the shaft till the connecting rod formed an angle with the piston rod. When the crank was at an angle of 45 deg., then the twist on the shaft would equal the length of the semichord of the arc described by the crank pin, that being the actual length of the leverage of the crank when in that particular position. The length of this semichord in the example we have taken would equal the sine of the angle formed by the crank with the horizon or $=4.24$, therefore the torsion here would equal, if there were no expansion of steam, $1{,}412.5 \times 4.24 = 5{,}989.000$ lbs. If now, we suppose the steam cut off at $\frac{1}{12}$ of the stroke, then, when the piston arrived at the position due to the crank being at the 45-deg. angle, it would be 1.76 units from the end, neglecting clearance, and the steam pressure would be then diminished, according to Marriotte's law, from 50 lbs. per square unit to a pressure found by dividing 50 by $1.76 = 28.4$, and, consequently, the torsion on the shaft then would equal the sine of the crank's angle, multiplied by 28.25×28.4, or $= 802$ lbs. $\times 4.24 = 3{,}400.48$ lbs. In all calculations, therefore, of the strength of crank shafts, the measure of expansion must ever form a factor. The formulæ may be stated thus:—S=sine of the crank angle with centre line of cylinder, P= actual pressure on piston per inch at that point of the stroke, A=area of piston. Then S.P.A=T. T=torsion of shaft, neglecting the angle of connecting rod.

Of the passengers killed in 1869, 12 lost their lives by collisions of trains, 4 by part of the train getting off the rails, 1 (a child) was killed by the carriage door on the off side giving way when she was leaning against it, 12 by alighting from or attempting to enter a train in motion, 1 (a child) by falling out of a train in motion owing to want of care on the part of his parents, 6 by incautiously crossing the line at a station, 2 run over at stations through their own want of caution, and 1 was killed by "incautiously looking out of a window when near a station, his head coming in contact with a bridge only $13\frac{1}{2}$ in. from the window."

RECENT EXPERIMENTS ON THE STRENGTH OF CANNON POWDER.

From "The Engineer."

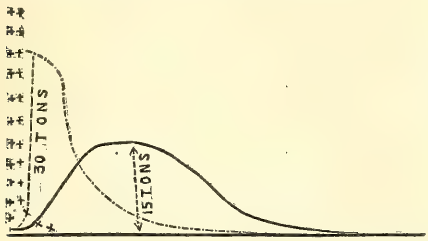
It has long been known to artillerists that the strength of gunpowder is conditionally variable, the conditions of variation being the quality of the ingredients, the proportions in which they are used, the methods of manufacture employed, the form in which the powder is burned, the system of ignition, and the weight of the charge. It is proper to add that the word "strength," when employed in speaking of gunpowder, admits of two interpretations. It may either be used roughly to define the strain exerted on the gun, or the force of expulsion exerted on the shot. Gunpowder may be strong in either or both of these senses. Thus a powder may be produced which will strain a gun excessively, while doing little work upon the projectile ; or, on the other hand, one which will strain the gun very little by comparison, yet impress a very high initial velocity on the shot. Up to a comparatively recent period, nothing more than is contained in the preceding statement was known. Even at the present day much remains to be done in the way of formulizing the effects produced by powder of different qualities burned under varying conditions. Piobert, Dalghren, Mallet, and Lynall Thomas have been the principal laborers in this interesting field of research. The results of ordinary practice, of experiments conducted in America and France, and other causes, induced our Government to take the matter up and conduct an experimental inquiry of an elaborate character, intended to settle : (1) The amount of pressure developed in the bore of rifled and smooth-bored guns of different calibres, by the employment of charges of gunpowder of different descriptions, and the law it follows. (2) The comparative merits of every variety of service gunpowder, and of any foreign gunpowders which might be procurable for trial. (3) The effect of igniting the charge at different points. (4) The effect of the length of the bore of the gun on the velocity of the shot at the muzzle. (5) The comparative merits of gun cotton in the smaller calibres. (6) The comparative merits of other explosive agents. It was anticipated that the result of the inquiry would settle what is and what is not the best powder for very heavy ordnance ; as regards small guns, the inquiry possesses second-rate importance. To carry it out, a committee was appointed in May, 1869, consisting of Colonel Younghusband., R.A., Superintendent of the Royal Gunpowder Factory; Captain Andrew Noble, late R.A, ; Captain W. H. Noble, R.A. ; Mr. F. A. Abel, F.R.S. ; and Captain Molony, R.A. The preliminary report of this committee has just been issued. Its importance demands immediate notice at our hands, but it must be borne in mind that few details of the actual experiments are given ; we think it better, therefore, at present to deal only with the substantial results obtained, reserving the experiments for future consideration when we have been placed in full possession of all the particulars.

Fifteen different kinds of powder have been tried, but the report before us deals only with 4 of them, which are R. L. G. service powder, 1867 pattern, and a new powder known as pebble powder No. 5. The following tabular statement shows the results obtained :

Nature of Powder.	Charge.	Muzzle Velocity.	Maximum Pressure.
	Lb.	Feet per Second.	Tons per Square Inch.
R. L. G. service.	30	1,324	29.8
Russian prismatic	32	1,366	20.5
Pellet service.....	30	1,338	17.4
Pebble No. 5.....	35	1,374	15.4

It will be seen at a glance that pebble powder promises to do more to aid us in the use of very heavy guns than any other modern invention. While ordinary large-grained powder imposed a strain of nearly 30 tons on the square inch of the gun, and yet imparted to the shot a velocity of but 1,324 ft. per second, pebble powder expelled the projectile with a velocity of 1,374 ft., and, in spite of the extra weight of the charge, only strained the gun with a pressure of 15.4 tons per

square inch. In other words, a gun burning pebble powder shonld last about four times as long as a similar gun burning L. G. powder. We say four times, because the damage done to a gun increases probably in even a more rapid ratio than the square of the strain upon it, even between such limits as 15 and 20 tons to the square inch. It is impossible to overestimate the importance of the foregoing results. Whether they will be confirmed in the case of heavier guns than that actually used in the experiments—one of 8 in. calibre, smooth-bore, firing 180 lbs. cylinder of iron—remains to be seen, as does the effect of rifling, windage, and numerous other points with which no doubt the final report of the committee will deal with exhaustively. A few trials which have been fired in a 10 in. gun are eminently encouraging.



It will be asked how it is possible that powder only exerting a propulsive strain of 15 tons per inch can drive a shot out of a gun with the same velocity as powder exerting twice the force? Mathematics would be out of place at the moment. It must suffice to explain that the action of the 15-ton powder, if we may so classify it, is prolonged over a greater period than that of the 30-ton powder. In the second place, less work is done in compressing the particles composing the shot and expanding the bore of the gun; in consequence, more effective work is done on the shot. This of course follows on the fact that pebble burns more slowly than rifle powder. It appears also that before the great bulk of the charge is ignited the shot has been started into rapid motion. The relative action of the two powders may be conveyed to the mind of the reader by the accompanying diagram, which it will be understood is only intended very roughly to illustrate the phenomena, not to formulize them. The dotted line denotes the action of rifle, and the full line that of pebble powder. The areas included between the respective curves and the base line show the work done in propelling the shot, but the vertical heights of the curves above the base show the strain thrown upon the gun, which may be independent of the areas altogether, as in the case of gun cotton which would probably give a curve similar in character to that shown by the line * * * * * * Copies of the diagrams, actually obtained in the course of the experiments, we hope to place before our readers in due time.

A very able investigation of the mutual relations of the material of a gun, and of the rapidity of explosion of the charge, will be found in "Mallet on the Construction of Artillery," page 127. We cannot better conclude this article than with a quotation from Mr. Mallet: "The researches of Piobert have shown that, as a determinable time is necessary before the inertia and compressibility of the shot can admit of sensible motion, so this maximum pressure is greatly increased, and the maximum more rapidly reached from the first instant of ignition, in proportion as the powder is of a quality to burn more rapidly; so that, carried to its extreme limit, as in the firing of some of the fulminating compounds, the gun is burst before the shot is sensibly moved, and the velocity attained by the latter is very slight."

The undertaking of the Indian Tramway Company, from Arconum to Conjeveram, about 19 miles in length, is incorporated in the Carnatic Company, and it is intended to extend that line to about five principal places in its route to Cuddalore. The extension line will be about 120 miles in length, and pass through a populous and fertile country. The exact route will be determined by the Madras Government. They will have to cross one large river and a smaller one. There may be a branch from the railway to Pondicherry, as the traffic there will be large.

The telegraph wires upon the line from Limerick to Ennis were maliciously cut near Clare Castle on Monday. The object of this malicious act is not known, and no arrest has as yet been made.

WIRE TRAMWAYS.

Condensed from "Scientific Opinion."

In the spring of 1869 Mr. Charles Hodgson, C.E., patented and published his method of Wire Tramways. The single trial line then constructed at Leicester so satisfactorily exemplified the inventor's method, that in the short space of 12 months more than a dozen lines have been constructed, and 14 are in course of erection in various parts of the world, the system having found especial favor in France where 7 lines are made use of in the carriage of beet-root, and so successfully, that the lessees of the patent are desirous of not only possessing the sole right to work the system in France, but also of buying up the inventor's royalty.

At the request of some gentlemen with whom he was in negotiation for the supply of materials for a line 60 miles in Ceylon, Mr. Hodgson has erected five miles of the proposed plant on Brighton Downs, to show, on an extensive scale, the advantages and capabilities of his system as applied to the carriage of produce and materials of all kinds over difficult country.

The wire-rope transport system may be described as consisting of an endless wire rope running over a series of pulleys carried by substantial posts, which are ordinarily about 200 ft. apart. This rope passes at one end of the line round a drum driven by either steam, water, or even horse power, in small farming operations, at a speed from 4 to 8 miles per hour. The boxes in which the load is carried are hung on the rope at the loading end by a wooden Λ-shaped saddle, about 14 in. long, lined with leather, and having 4 small wheels, with a curved pendant, which maintains the box in perfect equilibrium while travelling, and most ingeniously, but simply, enables it to pass the supporting posts and pulleys. By a sliding-ring arrangement the boxes or buckets are easily emptied by tilting without unshipping the saddle from the rope. The boxes can be made to carry from 1 cwt. to 10 cwt., and the proportions of the line and the loading and discharging arrangements can be varied to suit any particular requirement ranging from 10 tons to 1,000 tons per diem. At each end of the line are rails placed to catch the small wheels attached to the saddles of the boxes, by which means the weight, having acquired momentum, is lifted from the rope, and, thus suspended from a fixed rail or platform, can be run to any point for loading or emptying, and again run on to the rope for transport, the succession being continuous and the rope never requiring to be stopped for loading and unloading.

Curves of sharp radius are easily passed, as well as steep inclines, and its applicability to cross rivers, streams, and mountainous or hilly districts, will be apparent at a glance, as the cost of construction increases but little under such circumstances, whilst that of a road or railroad is, perhaps, increased tenfold, and the daily working cost doubled or trebled. The rope being continuous, no power is lost on undulating ground, as the descending loads help those ascending.

In the case of lines for heavy traffic, where a series of loads, necessarily not less than 5 cwt. to 10 cwt. each, must be carried, a pair of stationary supporting ropes, with an endless running rope for the motive power, will be employed; but the method of supporting, and the peculiar advantage of crossing almost any nature of country with a goods line without much more engineering work or space than is necessary for fixing an electric telegraph, without bridges, without embankments, and without masonry, exists equally in both branches of the system.

In the minor applications, such as short transport from mines to railways, the landing or shipping of goods in harbors and roadsteads, and the carriage of agricultural produce on farms, some peculiar features of the system render it specially advantageous. Amongst these are the facility with which power can be transmitted by the rope and taken off at any required point for mining or other purposes. In lines terminating on the seaboard, or on great rivers, a manifest advantage is secured in the facility for taking goods direct to or from ships in harbor or roadstead without transhipment into lighters.

Seen from a distance, the posts which carry the tramway wires at Brighton might be mistaken for telegraph poles, but a nearer inspection reveals a second line of wires on the same level, and upon these two wire-rope lines, supported on standards at intervals varying from 300 ft. to 1,000 ft. apart—according to the requirements of the ground—are suspended iron boxes for the carriage of the goods, which boxes pass on noiselessly and steadily, carried forward by the rope at the uniform rate of five miles an hour—the time required for performing the entire circuit of the line.

In laying out these five miles at Brighton the opportunity has been taken of exemplifying the working of the system under every variety of difficulty that could possibly present itself; thus we have at one part an incline of 1 in 6, up and down, which the rope and boxes work with perfect facility, the descending weights assisting those which are ascending; then there are, besides several bends less acute, two instances of absolutely right angles which are passed with the greatest ease; in some instances the standards are carried to the height of 70 ft. to meet inequalities of the ground, undulating and hilly country being more trying to this system than craggy and mountainous,—such as that for which this plant is designed, and where, from the long reaches taken, fewer posts will be required.

The line is rather over 5 miles long; there are 112 posts, or standards, in the whole length; these standards can either be made of light angle and band iron neatly put together, as in the present case, or of wood. The rope is made of charcoal iron, is 2 in. in circumference, each strand as well as the centre of the rope having a hempen core, to secure ductility. The power employed to drive the rope is a portable 16-horse power engine.

Some of the spans are 600 ft. and 900 ft. in length, and ingenuity has been shown in devising every possible mode of testing the merits of this system of transport; and we are bound to record that all difficulties have been overcome with complete success. The line is capable of delivering 240 tons per day of ten hours, *i.e.*, 120 tons in each direction.

It is intended to divide the proposed Ceylon line of 60 miles into 5-mile sections such as this,—one engine working every two sections, and the boxes passing each section by shunting arrangements, similar to those used at the termini, from one section to another. It is hardly likely that so efficient and economical a means of transport will be for long exclusively confined, as at present, to the conveyance of goods. For ourselves, we venture to confidently predict an early adaptation of the principle of this ingenious system to passenger traffic.

THE BULGING OF WALLS—CAUSE AND PREVENTION.

From "The Building News."

The ugly protruding curvature commonly called a bulge, to which external and front walls seem especially subject, may frequently be traced to original defects of construction. Bulges very often occur at about the level of a floor, and where there is a floor the brickwork of outer walls is commonly weakest. To avoid running the floor-timbers into party walls, they are generally made to rest on the front and back, and the party-wall will often appear in better condition than the front. Immediately below the level of the intended floor, a timber scantling about $4\frac{1}{2}$ in. by 3 in. is laid along the wall flush with its inner face, to receive the ends of the joists. The joists, let it be assumed, are about 10 in. deep, notched to 9 in. at the ends, so as to rise the height of three courses of brickwork. Here, then, bond-timber and joists together make a height of 12 in., or four courses of brickwork. The joists will have a bearing of 6 in. on the wall, and the wall may be supposed to be a brick and a half thick. Now wherever the joists occur, there is a complete interruption of the bond on the inner side of the work, while externally it appears unbroken, the outer face, in fact, being carried up half a brick in thickness, and looking as though the whole wall were perfectly solid and uniform; but the

backing between the timbers too often consists of bats and small pieces put together in a mysterious though incongruous way. So long as the timber remains sound and of its full dimensions, all is well, but this is seldom very long. The manner of converting balk timber into scantlings precludes the permanent retention of its original form. When felled and squared in its native forests, it is thrown into the first lake or river, formed into rafts, and navigated to some port of shipment, where it is formed into cargoes for conveyance across the ocean. The sea voyage over, it may be assumed to the port of London, the timber is again immersed in the water, which usually constitutes its only place of storage till wanted for actual application to some building. As to deals, an architect may specify dryness as a necessary quality, but he must not expect it in timber. He may say that it shall be sound and well seasoned, but water seasoning is all that takes place previous to conversion; and this fact is noteworthy, because as the subsequent shrinkage may be estimated at three-quarters of an inch in the foot, it becomes obvious that so far as the bond timber and joists are to be regarded as forming the inner material of the wall, a subsidence equal to the shrinkage must take place. But the wall does not depend on the woodwork alone, and the irregular filling up between the joists will receive the weight, and so the evil will be deferred. For the time there may be no other visible result than the dropping of the floor from the skirting, and when the latter is of wood, the simultaneous rising of the skirting from the floor. It is when the wooden bond, having shrunk to the minimum dimension of perfect dryness, enters upon its course of decay, that the worst consequences of inserting timber constructionally in walls are developed. The inner face then sinks, and the statical conditions are disturbed, and bulging is inevitable. It was a custom of bygone days to insert timber very freely in walls. Foundations were fortified, as it was thought, by the introduction of a "chain-bond" of large scantling, and many a goodly edifice has suffered from the practice. Great, therefore, have been the improvements adopted in the modern construction of walls. A solid basis is obtained by the use of concrete; wrought-iron hooping has advantageously displaced wooden bond, and the joists are kept as much as possible out of the walls, their ends being supported by brick or iron corbels. Thus all rapidly perishable matters are excluded, and a lasting character imparted to work so executed. Skirtings also are made of stucco instead of wood, and shrinkage in that quarter got rid of. Thus experience and science are gradually removing one of the old defects and disfigurements of buildings—the bulging of walls.

WONDERFUL FLY-WHEELS.

From "Engineering."

A contemporary of ours, in the course of an article intended to treat of economical steam-engines, has proposed, as the great panacea for all irregularities in the movement of mill engines, the use of enormously heavy fly-wheels; the application of a 60 ton fly-wheel, 28 ft. in diameter, to an engine with a 32 in. cylinder and 5 ft. stroke, run at 40 revolutions per minute, being spoken of in glowings terms as the acme of perfection. The writer, in fact, comes "to the conclusion that for pressures of about 100 lbs., and a tenfold expansion, it is better to employ a heavy fly-wheel than a second cylinder to insure regularity of motion;" and he further states that such a fly-wheel "costs, say, to begin with, £6 10s. per ton, if of large size, and when once up it never costs another sixpence." Now, we have no intention to enter, here, into a controversy with our contemporary as to the comparative merits of single-cylinder and compound engines; but we should like to direct the attention of the writer of the statements we have quoted to a simple little calculation which he may possibly find instructive. In the first place, we may remind our contemporary that there is such a thing as friction, and that, within certain limits, the power required to overcome the friction of any bearing varies directly as the insistant weight on that bearing. In the case of ordinary bear-

ings, such as those of a fly-wheel shaft, an allowance of 1-15th of the insistent weight for frictional resistance is a moderate one, and with the 60 ton wheel which our contemporary advocates, the frictional resistance of the crank shaft bearings would be quite 4 tons. Again, these bearings would have to be quite 15 in. or 16 in. in diameter, or, say, 4 ft. in circumference ; and when the engine was making 40 revolutions per minute, their surface speed would thus be 160 ft. per minute. From these data we see that the power required to simply keep such a fly-wheel in motion at the speed named would be :

$$\frac{4 \times 2240 \times 160}{33,000} = 43.4 \text{ horse power!}$$

But an engine with 32 in. cylinder, 5 ft. stroke, run at 40 revolutions per minute, and worked with steam at from 90 to 100 lbs. pressure expanded tenfold, would only indicate about 200-horse power, and we thus see that if the proportions which our contemporary advocates were adopted, about 22 per cent. of the whole power of the engine would be absorbed in driving the fly-wheel alone! How our contemporary can reconcile this fact with his statement, that the wheel, when once applied, would "never cost another sixpence," we are at a loss to imagine, and we are equally at a loss to know what advantage such a mode of procuring regularity of motion possesses over the practice of "compounding." We can assure the author of the article in our contemporary, also, that if he consults any one practically acquainted with the subject, he will be informed that the cost of replacing an ordinary 20 ton fly-wheel by one of 60 tons—with a view of being able to work 100 lbs. steam expanded tenfold in a single cylinder, without introducing objectionable irregularity of motion—would be far more than that of compounding the engine according to well-known plans. The particular engine with a 60 ton fly-wheel, cited by our contemporary as an admirable example of its peculiar views, was employed in working a rolling mill, and it is possible that, under the circumstances, the heavy fly-wheel may have answered tolerably well. But, even for driving rolling-mills, engines with heavy fly-wheels are getting out of date, the system of direct-acting quick-running engines, without any fly-wheel whatever, such as have been introduced by Mr. Ramsbottom, being found preferable in every way by all who have tried them. Our contemporary's ideas are evidently a few years in arrear.

IRON AND STEEL NOTES.

On Rolling Rails.—At a recent meeting of the Iron and Steel Institute (English), the discussion of Mr. Menelaus' paper "On Improved Machinery for Rolling Rails" elicited a vast amount of information. It seems that the object sought to be achieved in rail-rolling is to avoid stopping the rolls after each passage of the rail under treatment. It is not difficult to comprehend that with machinery running at only 40 revolutions per minute the loss of time and power resulting from reversal every time that 15 ft. of iron has been passed through is considerable ; and, if nothing else were learned at the meeting of the Iron and Steel Institute, all must have been convinced that the opinion which had still been entertained by some, that there was no loss of economy from reversing, was erroneous. Perhaps the most remarkable statement made in this connection was that of Mr. C. W. Siemens, F. R. S., who actually suggested that an advantage was obtained by stopping the engine as well as the rolls. For very heavy work, such a system may, indeed, be admissible under some exceptional circumstances, but, as it was objected, if it be unadvisable to stop the rolls, how much more so it must be to stop the whole of the machinery, even apart from the fact that by adopting Mr. Siemens's suggestion it is practically impossible to work two sets of rolls from one engine, which is frequently done at present. The loss of the accumulated power at each reversal becomes of itself an important item in connection with the cost of rail-rolling, and hence the efforts of practical rail-makers to keep their rolls continually going in one direction.

Assuming, then, that the desirability of avoiding the reversal of the rolls is admitted, the question naturally arises, how can that object be most easily and economically accomplished? The pile of iron, it must be remembered, is in a heated state, and has to be passed a certain number of times through the rolls whilst still soft enough to take the impression of them The use of hot rolls to prevent the abstraction of heat will scarcely be suggested, seeing that it is not required to effect the union of the rolls and the rails, although some of the suggestions appear but little more worthy of adoption. In devising a plan of operation there are necessarily many circumstances to be considered; yet, if simplicity can be combined with efficiency, the result should be a machine that would be generally adopted. The system of roll before roll has been suggested, and where large quantities of metal have to be rolled without change of section, may possess some advantage, but it seems to necessitate an enormously large plant for the performance of a given quantity of work ; it has another objection, to which reference will be made presently. The mode proposed by Mr. Menelaus for overcoming the difficulty consists in placing two pairs of

rolls, one a little behind and higher than the other. In using this arrangement the rail is passed backward and forward, but the rails are never stopped. The rail is passed through the bottom pair, then lifted and returned through the other. It will be seen that Mr. Menelaus has the advantage of two distinct pairs of rolls, very conveniently placed with regard to each other. The lifting of the end of the rail is, no doubt, an inconvenience, but it is a very small one—so small, indeed, as scarcely to be worthy of consideration. In another arrangement proposed by Mr. Brown, this lifting is avoided, but it seems that the remedy is almost worse than the disease. He has two pairs of rolls, one behind the other at the same level, each pair having blanks and working grooves alternately, the blanks in one pair being opposite the working grooves of the other. The rail to be rolled is passed through a pair of blanks in the first pair and rolled in working grooves in the back pair, and is then returned through blanks in the back pair and rolled in the front pair. The rail, instead of being lifted after each passage, is moved horizontally, and some of the practical men present seemed to consider the removal of the hot rail horizontally more objectionable, because more liable to twist it out of shape, than the lifting of it.

But that which promises to militate most against the introduction of Mr. Brown's arrangement is its extreme costliness. The stock of rolls has to be doubled for a given number of working grooves, and one-half of the roll surfaces become mere rollers, which do no useful work whatever. And as to changing two pairs of rolls instead of one each time a fresh section has to be rolled, there is is the same objection in the roll before roll system, in that of Mr. Menelaus, and in Mr. Brown's; hence the question raised by some—what is the advantage of reversing? Yet it was admitted the advantages of avoiding the reversal of the rolls far exceeded any supposed disadvantage, and that it was merely a question as to the best means of doing it. Roll before roll, the Dowlais rolls, and Mr. Brown's rolls all having objectional features, and the reversal of the rolls (no matter what means of reversing may be adopted) being more objectionable than either, the Ramsbottom rolls naturally claim attention. Mr. Ramsbottom has all the advantages claimed for the Dowlais rolls, and uses only a pair and a half instead of two pairs of rolls, and thus secures apparently the utmost attainable economy. The three rolls used by Mr. Ramsbottom run in one pair of standards, and being all geared together, the middle roll runs in the opposite direction to those above and below it; the rail can, consequently, be passed through between the bottom and middle rolls, and returned between the middle and top rolls, the whole of the machinery running in the same direction all the time. As in the other system of to and fro rolling without reversing the rolls, the end of the rail has to be lifted after each rolling, but in practice this really seems to be a very small inconvenience, so that, upon the whole, Mr. Menelaus' observation, that if he had another mill to put up at Dowlais, he did not know that he would not adopt Mr. Ramsbottom's plan even, instead of his own, is one which is worthy of the utmost consideration of all who are practically engaged in the rolling of rails. — *The Mining Journal.*

STATISTICS of IRON.—We owe the following datas on the production and consumption of iron in the various countries, to Dr. Beck. The numbers express hundred-weights, and have been collected for the year 1869:

	PRODUCTION.		CONSUMPTION.
	Per entire population.	Per individual.	Per individual.
Great Britain........	90,000,000	300	100
France..............	24,000,000	60	53
United States........	20,000,000	75	100
Zollverein...........	14,550,000	36	38
Belgium..............	7,250,000	100	65
Austria..............	6,750,000	18	19
Russia...............	6,000,000	5	8
Sweden and Norway..	5,000,000	100	12
Australia............	2,000,000	—	—
Spain................	1,200,000	6	10
Italy................	750,000	4	8
Total............	177,500,000		

MR. CHARLES M. PALMER, at a meeting of the Iron and Steel Institute in May, read a paper "On Iron as a Material for Shipbuilding, and its Influence on the Commerce and Armament of Nations." Fairbairn in a work on iron shipbuilding had pointed out the superior advantages which wrought-iron possessed over all other materials for shipbuilding. The iron plates of a vessel could be so riveted together that the joints would sustain a breaking strain equal, in double riveted joints, to 70 per cent., and in single riveted joints to 56 per cent. of the breaking strain of the solid plate, and this after taking into account part of the plate punched or drilled out in making the joints. It was also set forth as the result of, and deduction from, experiments that if the skin of a vessel could be made of wood 6 in. thick, without joints, that it would be equal to iron plating riveted together of 1¼ in. in thickness. This proportion was established on a comparison of the tensile strengths of the two materials, but so far superior were the facilities for the uniting of different pieces of iron to those of combining wood, that the 1¼ plating would be 134 times stronger than the wood sheathing combined in the ordinary manner used in wood shipbuilding. It was so difficult to fasten the wooden skin of a vessel that the combination was only 1-134th part of the tensile strength of the material. Iron ships weighed 35 per cent. less than the timber vessel, while the displacement of water was the same—greater strength was attainable, higher sailing qualities secured, and less strain liable in iron-built ships. The number of voyages made by iron screw colliers to and from London had risen from 17 in 1852 to 2,440 in 1869, while the tonnage carried in the same period had risen from 9,483 to 1,716,563. Taking the tonnage of British vessels built, he found that of timber there were in 1850 vessels carrying 120,895 tons, and 12,800 tons in iron vessels, while in 1868 the proportion was reversed. In that year the tonnage of timber-built vessels was 161,742, and iron-built vessels reached 208,101. The same marvellous increase of iron vessels over wooden was also seen in the amount of

steamers constructed. In 1850 the gross tonnage of wood steam vessels was 217 829, while that of iron was only 57,361 ; but in 1868 the tonnage of wood vessels was only 122,282, while that of iron vessels had risen to 1,341,106. America had not advanced iron shipbuilding, because labor was dear, and the manufacture of iron was a costly process. France had made no perceptible progress in adapting her mercantile marine to modern requirements. In England they had, amongst the vessels comprising the British navy, vessels of 130,150 tonnage, and 9,400 of a composite character. Shipbuilding in Holland was altogether on the decline. The Norway shipbuilding was entirely confined to timber vessels ; while respecting Italy, commerce was mostly carried on by English steamers. He was of opinion that the position already attained by England would enable her to keep a foremost place in commerce for some time to come. He would not, in conclusion, dilate upon the beneficial effects of the development of iron steam navigation upon civilization and the peace of nations. We have in a great measure substituted iron for wood. we must now change iron for steel, and he suggested the desirability of devising methods of cheapening and rendering practicable the use of steel in ship construction.

The Iron Trade in France.—Business is not so dull in France as it was a short time ago, but it can scarcely be said to be brisk; the orders from Paris are few and unimportant, but the state of affairs is better in the south. Rolled iron is in little request in the Haute Marne, but thin sheet, machine iron, certain kinds of special iron, axles rough and turned, wire, nails, and chains are in moderate demand. The long drought has had its effect, and several works dependent on water power have come to a partial or total stand. In the Moselle the metal trades continue in good condition ; work plentiful and prices firm. It is said that the ironworks of Pont a Mousson have engaged to deliver the cast-iron columns of six new furnaces which are about to be set up in France and Luxembourg by MM. Metz, De Dommeldauge and the concessionnaires of the Tongur and Ersch Railway. The Meuse has benefited by the strike of the iron founders in Paris ; the employers at the capital seem determined to withstand the demands made upon them, and are sending their models to be cast in the foundries of the Meuse, as well as in Belgium. The firm of Hayange, which has undertaken to supply the rails, plates, etc., for the Sedan and Séonville Railway, has contracted to do so, it is said, at 230f. the ton. A new house at Lille has just undertaken to furnish the Chemin de fer du Midi with turn-tables, at rates varying between 140f. and 231f. In Belgium merchant iron remains without animation, but sheet iron is in good demand, and the rates continue firm ; rails remain at the high price of 180f., which they have never before reached for ten years. The following are the average prices during the last ten years for rails of best quality, all accessory pieces supplied with them :

	Per Ton. Fr. cents.	Per Ton. £	s.	d.
1860	159 75 =	6	7	9
1861	161 50 =	6	9	2
1862	150 45 =	6	0	0
1863	149 20 =	5	19	0
1864	160 75 =	6	8	7
1865	161 80 =	6	9	5
1866	160 10 =	6	8	10
1867	156 70 =	6	5	4
1868	148 80 =	5	19	6
1869	158 25 =	6	6	7
Present price	180 00 =	7	4	0

The rate of exchange makes the English equivalents in the above table slightly too high—about 2d. in the pound sterling.—*The Engineer.*

RAILWAY NOTES.

Russian Progress.—The great feature at present in the material progress of Europe, is the activity which Russia is displaying in the work of railway development. The Czar's Government has laid aside for the nonce—although it may still perchance cherish them—its historic schemes of political aggrandizement, and has applied itself to the sounder and more pacific task of utilizing more fully the territories which it already possesses—territories which are surely vast enough, in all conscience. With this object, an extensive network of railways is being rapidly carried out, and Moscow has already become a terminus of six great lines. The effect of this extensive construction of Russian railways has been to give a stimulus to the production of rails in Great Britain, and all over the continent—in fact, the Russian demand for rails, and the revival of railway enterprise in the United States, are unquestionably the principal causes of the amelioration which has been witnessed in the British and European iron trade during the last two years. We have on more than one occasion directed attention to the aspect of affairs; and in support of our present argument, we would cite the exports of rails and railway iron made by Great Britain and Belgium to Russia during 1869, 1868, and 1867:

	1867. Tons.	1868. Tons.	1869. Tons.
Great Britain	124,693 ..	101,290 ..	252,827
Belgium	67,095 ..	45,430 ..	67,419
Total	191,788 ..	146,720 ..	320,246

If figures ever proved anything, they are conclusive, we should imagine, as to the powerful influence for good which the prosecution of Russian railways exercised last year upon the European rail trade. The figures are also interesting from another point of view, since they show that—for the present at any rate—Belgian competition is a bugbear. The fact is, Belgian means of production are so limited, as compared with those of England, that, even when Belgian competition has done its worst, it is scarcely felt in prosperous years. In 1869, Belgian production was taxed to the utmost, but we sent more rails than ever into Russia ; and although the aggregate exports of rails from Belgium to all countries increased last year to 136,063 tons, as compared with 70,550 tons in 1868, the aggregate exports of British railway iron also increased from 583,488 tons, in 1868, to 895,848 in 1869, showing a progress last year of 312,360 tons, or more than double the whole of the Belgian export. When croakers, who affect to believe in the decadence of British commerce,

begin to indulge in idle assertions and baseless vaticinations, they would do well to "read up" a few such facts as we have just cited.

It is not only in the matter of rails that Russia has made her influence felt of late as a great consuming State, but she has also had to purchase a large amount of rolling stock, engines, trucks, and plant. In all, contracts have been let for 1,200 locomotives for Russian lines during the last three years; and at £2,500 per engine, the money value of these contracts, cannot be taken at less than £3,000,000. Of the 1,200 locomotives, about 370 were ordered from English and Scotch firms, so that Great Britain obtained a solid slice of the £3,000,000—about £900,000. Orders of some importance for carriages and trucks, on Russian account, have also been received by several leading British firms and companies. It must be confessed, however, that we have not thus far been so successful in obtaining orders for rolling stock from Russia as in securing contracts for rails, a very large proportion of the locomotive orders given out having been secured by Prussian and French houses. Even Belgium has been set aside in the matter of Russian locomotives by French adroitness. Thus, when contracts for 30 locomotives for Russia were recently proposed to some Belgian works at £2,520 per engine, they stood out for £2,640 per engine, while the administration of the great French establishment at Creusot came forward and undertook the whole work at £2,472 per engine. Probably financial consideration firms were so terribly bitten with the almost valueless obligations of disappointing Spanish railways that they have probably not been very eager to accept Russian securities in payment for work and labor done. But French intelligence has appreciated the fact that there is a wide difference between obligations bearing the tangible and substantial guarantee of the Russian Treasury and the bonds of struggling Spanish companies. This difference is certainly very material, for Russian financial honor has never been impeached, and as the whole resources of Russia are pledged for the payment of the interest upon Russian railway bonds—at any rate upon such of them as bear the seal of the Russian Treasury—they are virtually State funds; at any rate, they bear the same proportion to Russian funds as Indian guaranteed railway debentures bear to Indian funds. It is credit which has carried French, English, and German locomotives into the heart of Russia; it is credit which has caused the great Russian railway network to spring into existence; it is credit which is securing to Russia all the material blessings of an advanced civilization.—*Colliery Guardian.*

Railways in Japan.—The city editor of the loan now being negotiated in this country: The London Stock Exchange, as the centre of the financial negotiations of the world, is about to open a new connection. A loan of £1,000,000 for the Imperial Government of Japan, contracted under the authority of Mr. Lay, as special commissioner, is introduced by Messrs. J. Henry Schröder & Co. The price is to be 98, and the rate of interest 9 per cent. per annum; the principal redeemable at par within thirteen years by annual drawings. The object is to connect by railway Yeddo, the capital of the empire, with Yokohama, Osaka, and the port of Tsuruga—points which comprise several millions of inhabitants and the most active trading communities of the country. As a special security the entire Customs duties of the Empire, said to amount to £600,000 or £700,000 per annum, are to be assigned, together with the proceeds of the intended lines, which are all to be completed within three or five years; and the Oriental Bank Corporation, who have had long experience of pecuniary intercourse with the Japanese Government and people, are to be the agents for the receipt and transmission of these funds. Although to external nations Japan is as yet a comparatively strange country, its capacities have been illustrated by the enormous development of its trade both with England and the United States during the past few years, and the conclusions of the various merchants engaged in this new and attractive branch of commerce seem favorable alike to the commercial sagacity and good faith of the Government and people. It may reasonably be anticipated that this sagacity and good faith will not break down in the commencement of their public monetary relations with the West, especially when those relations are established to supply means for augmenting their wealth, but will be so maintained as not only to justify any boldness our merchants may now be disposed to display by becoming investors, but to lead to a long financial intercourse, in which we may constantly increase our operations, and at the same time with safety gradually reduce the terms upon which they are undertaken.

ORDNANCE AND NAVAL NOTES.

Ships' Decks and Vertical Fire.—The trials which took place lately at Shoeburyness against a target plated and constructed to represent a ship's deck, proved very conclusively how defenceless even a stout modern iron-clad would be against a well-directed vertical fire, if such a fire could be delivered. The target consisted of six iron deck beams, 10 in. deep, protected by 1 in. iron plating (in two ½ in. plates) and an upper stratum of 5 in. deal planking. Over half the target the plating was 1½ in. thick (in two ¾ in. plates), the wood upon this portion being reduced to 4½ in. To avoid the delay and expense which would have resulted from vertical practice against a target placed horizontally, unless that target had been made of an extravagant size, the deck was placed upright, and the pieces were fired with charges calculated to give a striking velocity equal to that which the projectiles would have if fired vertically at considerable ranges and elevations. The attack was represented by the 13 in. sea service mortar and the 9 in. rifled howitzer, both placed at twenty obliged the projectile to strike at a considerable angle of incidence. The 13 in. spherical shell weighed, filled, about 200 lbs.; the 9 in. shell about 240 lbs. The charges were: 13 in., 7 lbs.; 9 in. howitzer, 3½ lbs. Only four rounds were fired, two against each portion of the target, one of these two being with each piece. Both the 13 in. went through the target, and one of the rounds with the 9 in. accomplished a like effect. After this not much argument is needed—if, indeed, it were needed before—to prove the terrible havoc which vertical or high-angle fire would be capable of producing upon ships of war; and the importance of vigorously prosecuting experiments

with a view to the introduction for coast defence of some pieces capable of delivering such a fire with tolerable accuracy. Hitherto the inaccuracy of high-angle fire has been the great obstacle to its success. This, coupled with a sort of impression that projectiles animated only with the velocity due to their falling weight would be easily stopped, has caused this subject to hang fire. Nevertheless, many competent judges have long urged the importance of the question; and for some years the introduction of an efficient piece for high-angle firing has occupied, off and on, the attention of the Ordnance authorities. It is time that those deliberations and experiments should bear fruit; and the results will, we hope, give the impetus to the inquiry which it has long needed. If we cannot get through the sides of modern ships, we can at least attack their bottoms by torpedoes, and introduce shells through their decks. What a very disagreeable place a ship will be to fight in ere long!—*Pall Mall Gazette.*

Experiments with the Moncrieff Gun-Carriage.—Yesterday, at 12 o'clock, A. M., the new gun-carriage, made in the Royal Gun-Carriage Factory of the Royal Arsenal, under the supervision of Colonel Clerk, R. A., the superintendent, from designs of Captain Moncrieff, for a 12-ton gun, was placed in position at the proof butts on the Plumstead Marshes, and practically tested in the presence of the Select Ordnance Committee and a large number of distinguished military officers and other gentlemen.

The barbette gun-carriage, which was mounted with one of Armstrong's 12-ton rifled muzzle-loading guns, is the first of the same size, and somewhat on an improved principle to the last made for a 7-ton gun, the lifting and breaking gear being more complete, and Captain Moncrieff has also added an apparatus for lifting the shot to the muzzle of the gun, which is a decided improvement. The following are the weights of the different parts:—Carriage, tons, 2-5½; platform, tons, 9-1; and elevator, tons, 14¼; balance, tons, 15-1⅜; total gear, 67 tons. Before the experiments commenced, Captain Moncrieff explained to the visitors and the committee the various parts of the carriage, and pointed out the new rear axletree to the elevator, which had been made since the trial in private last week. About 12.15 the gun was loaded with a charge of 30 lbs. and a shot of 240 lbs. and gently raised into position and fired, when the recoil was very satisfactory, bringing the great gun down into rest with the greatest ease. The next charge was increased to 40 lbs. powder. In ramming up this time, the pull of the rack on the right side was allowed, by the man attending to it, to properly, and it had to be worked back to free the pull again. On examining the pull-pin it was found to be bent, which necessitated the removal of the right pull altogether; and after the firing of this charge the gun recoiled with admirable ease to the full; but, as the supports had slightly shifted, these temporary adjuncts were strengthened, and then the gun was again raised and fired with a charge of 43 lbs. when, strangely enough, the recoil thrust the whole platform forward about half an inch instead of rearward. The whole of the experiments, however, were pronounced to be highly satisfactory, and Captain Moncrieff received the congratulations of the officials present, when he explained that the experiments had been made at great disadvantage. The gun, in getting into firing position, rises on the elevator to the height of 13 ft. 3 in., and the area required for the platform to work freely is 19 ft. by 11 ft., and the shot used at each service is a 250 lbs. round iron cylinder. At the conclusion of the tests a minute inspection of all the gear and the carriage was made, and as everything was found to be in complete working order, Sir Hope Grant and Sir David Wood, with the members of the Ordnance Select Committee, congratulated the inventor on the success of the experiments. Captain Moncrieff said he intended to simplify the carriage supports considerably.—*Army and Navy Gazette.*

The alteration of the Prussian needle-gun has been sanctioned by the King, in consequence of which the two or three millions of rifles in the possession of this Government will be remodelled. The improvements introduced aim at simplifying the loading, and increasing the force and range of the ball. For this purpose the caoutchouc ring of the Chassepot has been adopted, which, helping to close the breach by spontaneous action, renders it unnecessary to press the valve down so tightly. In addition to this, the weight of the ball has been reduced from 31 to 21 grammes, which, with the charge remaining at 4.9 grammes as formerly, considerably augments the propelling force. To fit the reduced ball for the old barrel the *zund-speigel* has been proportionately enlarged, a proceeding, the practicability of which was proved by a similar alteration adopted some time ago, and further attested by a year's experiments with the weapon in its present, latest form. On the needle-gun being first taken into favor in 1841 it had a ball of 15.43 millimetres, but the heaviness and consequent want of speed observable in the missile causd it to be soon reduced to 13.6 millimetres, which size has now been further diminished to 12 millimetres. The total weight of the new cartridge is 32 grammes, instead of 40 grammes, as heretofore, so that the soldier will henceforth carry 95 instead of 75 cartridges, without experiencing an additional burden. Besides this, the needle is now made to move in a narrow hole, into which it fits exactly, instead of the wider one of the old gun, and a piece of oiled paper is placed at the bottom of the cartridge to clean the needle after each discharge, and serve some other purposes of minor importance. By these improvements it is hoped to raise the Prussian needle-gun, which has the glory of being the first breech-loading rifle ever introduced into an army, to the latest requirements, and make it practically a match for all its manifold rivals. Though among these latter there are some with a ball of only 11 and even 10 millimetres, it is contended is of no practical use in the field, and that the Prussian rifle, in its present form, fires quite as rapidly and as far as the purposes of warfare require. That the alterations resolved upon are not very costly is owing to the ingenious construction of the *zund-spiegel*, which admits of a small ball being shot out of a comparatively wide barrel.

Mr. Childers on Whitworth Guns.—Mr. Childers' argument for undertaking expensive experiments with Whitworth guns is worthy of notice. It runs as follows: The navy are thoroughly satisfied with the service 12-ton guns; they consider also that the trials of the service 25-ton gun "have been entirely satisfactory." But they require more

powerful guns for ships of the Devastation and Thunderer class. Therefore they propose—what? Not, as would naturally follow from the foregoing reasoning, to make these new and more powerful guns of the construction which, up to 25 tons—that is to say, as far as it has been tried—has been "entirely satisfactory," but to run off the line and to try quite a different weapon. Sir Joseph Whitworth himself is very fond of appealling to the results of experiments made with some tiny model gun, as a 1-pounder or a 3-pounder, as evidence of the infallible success of his shot, or his metal, or his system, when applied on a larger scale. Mr. Childers reverses that process. From the admitted success of a 25-ton and other service guns, he argues the necessity for the introduction of a totally different system of ordnance. Of course this process of reasoning will lead you exactly where you please. If the success of a system be an argument for altering it, the failure of a system may naturally be accepted as an argument for introducing it. Hence the Whitworth gun which, as we have before shown, was reported unsuited for her Majesty's navy when tried in 1867 as a 7-ton gun, is now to be tried on the 35-ton scale.—*Pall Mall Gazette.*

A new method of testing thick armor for her Majesty's ships has been introduced during the past week at Portsmouth in the trial of two immense plates for the Glatton and the Devastation breastwork monitors. Hitherto the practice has been to fire at the plate with spherical shot from the smooth-bore 8-inch gun, but the method now brought into use by the Admiralty substitutes the 7-inch muzzle-loading rifled gun with chilled shot for the smooth-bore. The powder charge varies according to the thickness of the plate under test in the following degrees: For 12-inch plates 21 lbs.; for 11-in. plates, $18\frac{1}{2}$ lbs.; for 10-in. plates. $16\frac{1}{2}$ lbs.; for 9-in. plates, 14 lbs. The distance between the gun and the plate is 30 ft., and four shots are fired at the plate within an area of two sq. ft. The plate for the Glatton was from the rolling mills of Messrs. Charles Cammel & Co., Cyclops Iron and Steel Works, Sheffield, measuring 10 ft. in length, 3 ft. 6 in. in breadth, 12 in. in thickness, and weighed 7 tons 2 cwt. The plate for the Devastation was from the rolling mills of Messrs. John Brown & Co., Atlas Iron and Steel Works, Sheffield. Its dimensions were 14 ft. in length by 4 ft. 6 in. in width, and 10 in. in thickness, and weight 10 tons. The average penetration of the shots in the 12-in. plate was 7.2 in., and in the 10-in. plate the penetrations were 6.3, 6.8, 6.8, and 7.8 in. respectively. It is a remarkable feature in the manufacture of these enormous slabs of iron for our new turret-ships that they are bent to the required form direct from the rolls, and when at cherry heat. To bend such plates cold would give them a certain amount of brittleness, and render them liable to "star" when struck by shot.

Accounts from Cherbourg state that the Imperial yacht L'Hirondelle during one of her late trial trips acquired a speed of 14 2-10 knots, and that from the time the fires were lighted, only 20 min. elapsed before the steam was up and the vessel ready to start. L'Hirondelle's power is equal to 1,800 horses.

A new Victorian flag, which, at the suggestion of the Admiralty, has been designed as the distinguishing mark of the Victorian mercantile navy, has been formally adopted by the Government. The ensign will have five white stars on the blue ground, and the "jack" five white stars in the cross of St. George, which forms the central line of the pattern.—*Melbourne Argus.*

The experiments carried on by the special committee during the past week at Shoeburyness, under the presidency of Colonel Elwyn, Royal Artillery, Commandant of the School of Gunnery, assisted by Capt. Arthur, R. N., and Major Millar, V. C., Royal Artillery, to test Sir Joseph Whitworth's 9-in. $14\frac{1}{2}$-ton steel muzzle-loading hexagon bore rifled gun, for range and accuracy, were resumed on Wednesday. The gun up to this date has fired 118 rounds, with 50 lbs. rifle large grain powder charges, and shot and shell of about 115 lbs.

The Portuguese Government are asking for a supply of 10,000 rifles on the Martini-Henry principle, and 1,000,000 cartridges, also for 14,000 butt ends for Enfield rifles and 1,000,000 cartridges for the Snider arm.

The new iron armor-plated double-screw ship Invincible, 14, ran six hours in the Channel, outside Plymouth Harbor, on Saturday, being three hours to the westward and three back, with a very satisfactory result.

ENGINEERING STRUCTURES.

The Darien Ship Canal.—Whatever advantages might result to the commerce of the United States, and of the world, from the opening of an inter-oceanic ship canal across the Isthmus of Darien, the practicability of such a work is dependent upon the discovery of a depression in the Cordilleras by the Government surveying party now on the ground. As yet, the accounts received of the progress of the survey do not promise much for the success of the expedition, except that it has disproved the theories of Gisborne and Cullen and conclusively demonstrated that the narrow pass or valley, which the latter claims to have discovered, extending from ocean to ocean, has no existence save in the imagination of its pretended discoverer. This is certainly discouraging, although the explorations and surveys will be continued in the hope of finding a practicable route through some other section of the Isthmus.

From a somewhat intimate knowledge of the topography of the narrow strip of land uniting the two continents, we incline to the belief that, with the exception of the pass now occupied by the Panama Railroad, there is no depression in the mounta n range through which a canal could be projected. Unless such a depression is discovered, however, the canal project may as well be adandoned, as far as Darien is concerned. The tunnelling scheme, proposed by some impractical genius, which proposes to cut a tunnel "of sufficient capacity to pass the largest-sized man-of-war, with topgallants lowered and yards squared," through from 5 to 7 miles of mountain, will never for a moment engage the serious attention of capitalists. It is doubtful, therefore, if a suitable route will be discovered across the Isthmus; but even if the engineering difficulties are found to be less serious than

at present supposed, others exist touching its practicability when finished. The most important of these is that it would be available for steam vessels only. Sailing vessels would not only have to be towed through the canal, but, before they could be fairly started on their way across the Pacific, it would also be necessary to tow them from 150 to 200 miles out to sea. During the greater part of the year the entire section of coast from the equator to 15 deg. north latitude, is free from winds available for sailing vessels. Geographically it is known as the region of the southeast and southwest monsoons, and extends from about 9 deg. south latitude to the Equatorial Calm Belt, which touches the southwest coast of Tehuantepec at about 15 deg. north latitude ; and longitudinally from 78 degs. to 119 degs. west from Greenwich, including within these limits the entire west coast of Central America, Darien, Columbia, and Equador. During most seasons this is a region of prevailing calms or light baffling winds. —*The Iron Age.*

A New Motive Power (?)—Considerable ingenuity has been shown by Mr. Robert Side, of 126 Union street, Borough, in the combination of certain mechanical powers by which he claims to produce a machine which can be worked at a considerably cheaper rate than engines worked by steam, gas, or air. The substance of the invention consists in the use of cranks working in pairs one within the other, or opposite to each other in opposite directions, for imparting a rocking motion to weighted beams having no fixed axes of motion, but so constructed that the crank pins move in slots in the beams. We recently inspected a working model of this invention, as well as the same arrangement on a large scale, with which Mr. Side proposes to produce an engine of 5-horse power. The apparatus consists of two horizontal shafts lying parallel with each other, and connected by toothed wheels, which impart rotary motion to the shafts in opposite directions. The shafts are cranked and are so adjusted that the cranks move one in the other during rotation. The cranks terminate in pins which take into two slots in a balance beam. As the shafts revolve, one of the cranks falls outwards and the other rises inwards ready to be forced down in its turn by the falling end of the beam. A very slight force exerted at one end of the beam causes that end to descend, the gravitating power operating upon the cranked shafts, and thus imparting rotary motion which is to be transmitted by gearing for application to any desired purpose. A fly wheel assists the lever beam past the dead points. The novelty in this invention consists in having two revolving centres instead of one fixed centre. By this means every pound of pressure is thrown on the descending crank or centre, and becomes so much motive power. The inventor calculates that having a beam equal to 1-horse power and adding 1-horse power of steam on the upper end of the beam, he will then be working with 2-horse power, one of iron and one of steam, thus saving 50 per cent. of steam power. But it appears that it is not necessary to have a pressure of steam equal to the weight of the beam, as it only requires a pressure equal to 1-16th part of the weight of the beam to rock it from one centre or crank to the other. Hence Mr. Side states that a saving of 90 per cent. of steam power results. We are by no means so sanguine as to endorse this opinion, but the question is interesting, and we await the completion of the large engine to test the actual results.—*Mechanics' Magazine.*

The Causes of the Richmond Disaster.—More recent investigation assigns to other causes than those hitherto alleged, the fall of the room lately occupied by the Court of Appeals in the Capitol building in Richmond. It is now denied that its floor was ever supported by pillars beneath in the room called the Hall of Delegates, either before or after the hall was constructed. The size of the latter is 80x34 ft. Over it were two rooms whose floors rested on four girders dividing five spaces each about 16x34 ft. The girders were spliced timbers 13x20 in. in thickness, the first one from the eastern wall being under the floor just in front of the railing of the Supreme Court bench, and the second midway from that to the partition between the two rooms. In the centre of this second girder a mortise had been let in from above—with reference to some former columns of partitions—of 4x6 in. and 15 deep, reducing the material at this point to about 9½x20 in. The girder itself was of brittle heart-pine, and had otherwise been weakened by mortise and auger-holes. Finally, on this second girder there rested the pillars of a gallery within the room where the disaster took place. The room itself was about 34x50 ft. ; deducting the bench inclosed by the railing, a space of about 34 ft. square was closely packed with as many persons as could stand in it, and in the gallery which stretched across it. All that supported the weight in the centre of this space was the girder we have described. When it gave way it carried with it the gallery, and the entire plastering from the ceiling of the room also fell, with its framework. The floor took a funnel shape at the moment of the occurrence. Girder No. 1 remained unbroken ; No. 2 broke in the centre ; No. 3 cracked, but still remains, supported by a prop since placed beneath it. The entire mass of about 400 people, the gallery, the ceiling and its framework, fell together through the funnel-shaped cavity, a distance of about 25 ft. to the floor of the hall below. It will be recollected that inside alterations that weakened the supports were believed to have much to do with the recent fall of the wing of the Court House in Chicago. In the present case the building itself is not believed to be insecure.—*New York Tribune.*

The Navigable Dock.—The author commenced by stating that the improvement of the navigable dock had for the last ten years occupied the attention of the Institution of Naval Architects. Ordinary floating docks or lifts could only be deemed, when they reached their destinations, as simple *succedanea* for the ordinary dock constructed on *terra firma*, and in positions where the rise and fall of the tide was so small that they could not be made available for the great vessels of which their present navy was composed. The difficulties attending a mere floating dock were very great. The difficulties of transportation and expense, added to the slowness of the process, seemed to demand some more reasonable mode of relief. The desired result could only be obtained by one firm connected structure, totally independent, sound, and complete as any steamship, and capable not only of caring for herself, but perfectly adapted to rescue and safely house at sea, in moderate weather, the

largest iron-clad they now possessed or might intend to construct. His investigations and experiments resulted in the form proposed, and which he called a serviceable self-reliant ship dock, combining within her own accommodation every requisite to be sought for, not simply in foreign dockyards, but equal to any of the home dockyards. The Admiral then, with the assistance of diagrams, described his floating dock, the length of which he stated to be 500 ft., the extreme breadth 110 ft., the displacement at 27 ft., 25,000 tons, weight of the vessel and engines 13,000 tons, horse-power 6,000 tons, speed 10 knots. This would give the means of docking vessels requiring repair, of saving the necessity of a return to England, or to any place distant to seek for relief if disabled; and finally, with an unexampled power of despatch of examining, cleaning, and repairing a whole fleet in succession. As to despatch, the power of the turbine—that of removing 2,000 tons per minute—would in that minute fix the Warrior on her block, thus removing all the labor or anxiety as to her floatation. Seven minutes would raise her keel to the sea level, and twelve minutes would raise her 3 ft. above the wash of the sea.—*Mechanics' Magazine.*

Steam Colliers.—Among the many improvements and enterprises brought before the public during the past year, there is none more important than the introduction of iron steam-colliers on our coast, and for this we are indebted to Mr. Walworth D. Crane, a young New York merchant, who for three years past has labored incessantly to establish the line. In June last the pioneer ship, the Rattlesnake, 500 tons cargo capacity, made her trial trip on the Delaware river. This vessel was followed by the Centipede, Mr. Crane making some improvements in her construction, and in September last he placed four more under contract, viz.: the Achilles and Hercules, 1,000 tons each; the Panther and Leopard, 800 tons each; and these last-named reflect credit upon his sagacity and skill.

The benefits of cheap coal transportation from the great shipping points cannot be too highly estimated; and, as New York and its adjacent ports on the Hudson river are becoming the great depots for coal, it is here our merchants and manufacturers must look for supplies, instead of depending upon Philadelphia, which is the terminus of only one coal-carrying road, while here we have the outlet of the Delaware and Hudson Company, the Delaware, Lackawana, and Western Company, the Pennsylvania Coal Company, the Wilkesbarre Coal and Iron Company, and of the products of numerous individual operators. New York, as the metropolis, and on account of its geographical position, must become the great coal mart of the country.—*N. Y. Tribune.*

NEW BOOKS.

Crookes and Röhrigg's Metallurgy. A Practical Treatise on Metallurgy, adapted from the latest German edition of Prof. Kerl's Metallurgy, by Wm. Crookes, F. R. S., etc., and Ernst Röhrig, Ph. D., M. E. 3 vols. London: Longmans, Green & Co. New York: John Wiley & Son, 1868–1870.

Prof. Kerl's "Handbuch der metallurgischen Hüttentunde" (4 vols., 1861-65), of which "Crookes and Röhrig's Metallurgy" is essentially a translation, is almost the only reeent work which contains a full and detailed statement of the whole subject. Since Karsten's treatise (1831-32) metallurgical literature has been more or less fragmentary. Scheerer's "Classical Lehrbuch der Metallurgie" (1848–53) did not reach the completion of its second volume. Rivot's "Traité de Métallurgie" (1859–60) likewise remains unfinished; and English readers have been waiting impatiently for many years for Prof. Percy's concluding volume. A translation of Kerl's treatise into English is therefore timely.

The design of the translators was not merely to translate, but to adapt Kerl's work to the wants of English and American metallurgists. Many portions have been condensed and many omitted altogether, while considerable new matter has been added to represent the progress of metallurgy since the completion of the original treatise.

The recent appearance of the third and concluding volume enables us now to judge of the work as a whole.

As a translation, the work is marred by haste and carelessness, and by what looks, in some instances, very much like unfamiliarity with German terms and usages; as may be seen from the following extracts:

In Kerl, iv., 370, we read:

"Die Röstung wird so lange fortgesetzt, bis eine genommene und ein wenig angefeuchtete Probe nach *einigem* Liegen an der Luft keine Reaction *auf* Eisenvitriol mehr gibt."

This is rendered, i., 637:

"The roasting is continued until a slightly moistened sample has no reaction *upon* iron vitriol after *long* exposure in the air."

What the significance of any reaction upon iron vitriol would be in this instance, it would be hard to say.

Kerl, iv., 416, we read under the heading "Scheidung des Goldes vom Kupfer:" "*Mittelst Quicksilbers* lässt sich das Gold nur unvollständig ausziehen."

Crookes & Röhrig render this, i., 674, by the absurd statement:

"Gold cannot be perfectly separated from copper."

Kerl, iv., 379: "Vor der Behandlung des Röstgutes mit unterschwefligsauren Salzen empfielt sich ein Auslaugen desselben mit Wasser, wil Kiss es thut, *nicht*, weil das Goldchlorür in heissem Wasser sich sogleich in Chlorid und metallisches Gold zerlegt, in kaltem Wasser zwar unlöslich ist, aber davon im Dunkeln line zersetzung auch langsam erleidet."

Crookes & Röhrig, i., 646: "It is advisable to wash the roasting mass with water previous to its treatment with hyposulphites. The chloride of gold by the action of hot water, is decomposed into protochloride and metallic gold, and though insoluble in cold water, is slowly decomposed by it in darkness."

The omission of the negative may have been an oversight, but the use of roast*ing* for roast*ed*—a mistake of frequent occurrence throughout the book—and the confusion of the different chlorides of gold, cannot be accounted for on any such charitable hypothesis.

Kerl, ii., 611: "Damit die gaare nicht sofort beim Niederschmelzen des Kupfers eintritt, schlägt man Kupferhaltige Eisensauen zu."

Crookes & Röhrig, ii., 254: "To prevent the refining taking place at the smelting of the copper, cupriferous iron deposits are added."

Kerl, ii., 58, gives the lead production of Carinthia by the "Aerar" and "Privatwerke" separately. The translators seem not to have known that the terms *Aerar* and *aerarisch* (Latin Aerarium) are in general use in the Austrian empire in the sense of *governmental*, or perhaps have presumed that English readers would know what was meant by "the Aerar Smelting Works."

It requires no diligent and patient search to discover inaccuracies of translation such as the above. Any one acquainted with Prof. Kerl's work will notice similar inaccuracies—some important, others slight—on almost every page of the first volume, and although the second volume is generally more accurate, it is not by any means free from very bad blunders.

Appreciating fully the difficulty which the editors experienced in translating technical terms, for which there is no precise equivalent in English, we will not criticise severely the terms they have have chosen, objectionable as many of them are. But the ever recurring confusion of terms is a fair subject for complaint.

We have, for instance, the term *Ofenbruch* applied to the adhering masses broken from the walls of furnaces at the end of a campagne, translated in some places by "soot," in others, "metallic soot," and again by "metallic fume," neither of which strikes us as the best possible. But any one of the three, properly defined and adhered to, might answer. What makes it still more confusing is, that "Rauch" from lead furnaces, applied in the original to something entirely different from Ofenbruch, is translated indifferently by "lead fume;" "lead smoke," "metallic fume," or simply "fume," and again, "Flugstaub" is also translated by "smoke," "metallic smoke," and "metallic fume." The same confusion is noticed in translating the three related terms *Abzug, Abstrich* and *Bleidreck*. Saigern is sometimes correctly translated by *liquation* and at other times by *melting*. The confounding of *smelt* and *melt* is common throughout the work. Bleiische Zuschläge we find translated "fluxes," and Vorschläge sometimes "fluxes," and sometimes "dross." Such errors could only have resulted from ignorance of the sense in which these terms are used by German metallurgists.

But it is not only with the technical terms that the translators have made such sad work. A too rigid adherence to the German idiom has often made sentences almost unintelligible. Were we to cite some of the long complicated passages which show an attempt on the part of the translators to make English words conform to the rules of German syntax, we should consume too much space. We will only mention, in passing, the translation of "eigentliche Silbererze" by *real silver ores*, and the following amusing rendering :

Kerl, ii., 593: " . . wobei ein grosser Theil des Kupfers chlorit . . . wird."

Crookes & Röhrig, ii., 241 : "Thus a great part of the copper *chlorinates*."

The invariable use of the English comparative in translating such words as "grösseres," "längeres," "höheres," etc., which in the original imply no comparison, but merely "rather large," "moderately high," and the like, is not only very perplexing to the reader from the absence of the expected particle *than*, but in most cases conveys an impression not intended in the original.

Should we continue citing the inaccuracies of translation which we have noticed in reading the the work, we could fill a small volume, but the above are fair average specimens of the way in which Kerl's treatise is presented to its English readers.

Although faulty translation is the principal defect of the work, we have also to complain in some instances of a too faithful adherence to the original. The latter contains some evident misprints and misstatements—no work of its size and character can be, in the nature of things, entirely free from them—and these are generally reproduced in the translation ; the original contains no table of errata. Besides, there are many processes described by Kerl as in operation at the time his work was written, which have since been superseded by others ; yet the English edition gives them without any intimation of their having been abandoned.

This, we think, can only be explained by supposing the translators ignorant of the present state of metallurgic practice in Germany, and that the translation was undertaken without the advice and assistance of Prof. Kerl.

Conspicuous among the parts of Kerl's treatise which are entirely omitted in the translation, are the methods for assaying ores. This omission is justified by the translators "as the new edition of Mitchell's 'Manual of Practical Assaying,' fully treating of this subject, may be considered as adequately representing that branch of metallurgy." As Mr. Crookes is the editor of this new edition, we admit that from his stand-point this reasoning is just, but we venture to think that those practically interested in assaying would find Kerl's treatment of the subject much better than that of Mitchell and Crookes. A serious omission of a different character is, that no mention is made of Mr. Wurtz's name in connection with the sodium-amalgamation process. Mr. Crookes, as is well known, claims to be an independent discoverer of this process, but has already acknowledged in the "Chemical News," of which he is editor, that Wurtz's publications on the subject were prior to his own. In the work before us the editors devote considerable space to what they term "Mr. Crookes' process of extraction by means of sodium-amalgam," giving mainly testimonials of scientific authorities and practical metallurgists to the great value of Mr. Crookes' discovery. Mr. Wurtz not only comes in for no share of the credit, but Prof. Silliman's statements, made before the National Academy, Washington, 1866, concerning the results of his experiments in testing the value of Mr. Wurtz's process, are coolly taken by Mr. Crookes to swell his own praise! This evidence of petty selfishness on his part will not tend to enhance his reputation as a truthful and impartial author. As said before, much new matter has been introduced into the English edition. This has been largely taken from Dr. Ure's Dictionary of Arts, Manufactures and Mines (1860), though considerable matter is derived from other and more recent sources. This is principally seen in the third volume, where the subject of steel has received an extended, and, on the whole, excellent treatment. The Supplement to the last volume, comprising over two hundred pages, is intended "to bring the work to the level of the actual state of the science and practical experience," and is made up of "articles and reports on improved processes from some of the English and foreign journals." In compiling this

Supplement Messrs. Crookes and Röhrig have shown very little industry and discrimination, and have entirely neglected their duties as editors. Some of the articles, such as "Bell, on the Chemistry of the Blast Furnace," are most excellent, and need no pruning, but many of them are merely specifications of patent processes, not in actual operation and often wanting in novelty.

Gruner's detailed description of the desilverization of lead by means of zinc, in his admirable monograph, "Etat actuel de la Métallurgie du Plomb," published in the "Annales des Mines" (1868), is only given in an abridged form taken from a translation in an English technical journal. Not only is the monograph not mentioned, but the valuable details of the process as actually practised, together with drawings of apparatus, are entirely omitted.

The above criticisms have not been written with any hostile feelings towards the work or its editors. The writer being familiar with the original, and considering the names of the translators sufficient guarantee of the correctness of the English edition, heartily recommended it without examination. But he found, after careful perusal, that it was so grossly inaccurate as to be useless for his purpose, and he wishes therefore to put others on their guard against relying too implicitly on the work as a reproduction of the excellent and well-known treatise of Prof. Kerl.

Spon's Tables and Memoranda for Engineers. —Selected and arranged by J. T. Hurst. London: E. & F. N. Spon. For sale by Van Nostrand.

It is certainly an extremely rare thing for a reviewer to be called upon to notice a volume measuring but 2½ in. by 1¾ in., yet these dimensions faithfully represent the size of the handy little book before us. The volume—which contains 80 printed pages, besides a few blank sheets for memoranda—is in fact a true pocket-book, adapted for being carried in the waistcoat pocket, and containing a far greater amount and variety of information than most people would imagine could be compressed into so small a space. The book commences with notes about excavators' work, and these are followed by others on bricklayers' work, bricks, and tiles, masons' work, the weight of stones, limes, and cements, slaters', carpenters' and plasterers' work, and various useful particulars relating to the materials employed. Then come notes on smith and foundry work, tables of the weight of bar-iron of different sections, of the weight of plates or sheets of various metals, of cast-iron pipes, and of wrought-iron bolts, wire, nails, etc. These matters are followed by rules for proportioning wheels, and various tables and data relating to the strength of materials, and after these again come memoranda relating to plumbers' work, painting, glazing, and paperhanging. Then we have a table giving the weight per cubic foot of about one hundred and fifty different substances, and a variety of data of a similar kind; besides a table of tangential angles for railway curves, regulations for railway road crossings, an epitome of mensuration, tables of circumferences and areas of circles, and tables of foreign moneys and of English and foreign weights and measures. A few memoranda relating to hydraulics, the flow of water and gas through pipes, etc., might, we think, have been added with advantage, even if some of the data at present contained in the book—such, for instance, as some of the tables of the weight of nails and of the weight of round cast-iron—had been omitted to make room for them. A few rules might also have been included in the part devoted to the strength of materials, which would have materially increased the value of the book to mechanical engineers. On the whole, however, the little volume has been compiled with considerable care and judgment, and we can cordially recommend it to our readers as a useful little pocket companion.—*Engineering.*

First Principles of Chemical Philosophy. By Prof. J. P. Cooke, Jr. Welch, Bigelow & Co. For sale by Van Nostrand.

Beginning with clear definitions of volume and weight, the simple relations which exist between them when expressed in terms of the French metrical system are pointed out. Then the advantage of the employment of the *crith* in chemical calculations. By reasoning from the phenomena of expansion on increase of temperature, it is shown that the movements of the molecules make themselves known as heat, and that the temperature of a body may be expressed by the general formula for the momentum of a moving mass, or $\frac{1}{2}mV^2$. The argument is given for assuming as one of the fundamental doctrines of the new chemistry, that equal volumes of all gases, at the same temperature and pressure, contain the same number of molecules. The way of arriving at the numbers most approximate to the true atomic weights, is stated, and the exact value of the control exercised by specific heats upon the calculation. Also the manner of computing from the symbol of a substance its percentage composition, and the way of arriving at the molecular weight of a body in the liquid or solid state by comparison with substances whose molecular weights are known. The chapter on equivalents illustrates clearly the meaning of the terms quantivalence and atomicity, and that on types the manner of representing the constitution of compounds by graphic symbols. The inorganic acids, bases, hydrates and salts are brought into harmonious relations on the new system, and a similar harmony is shown to reign among various classes of organic compounds, such as the alcohols, fats, ethers and glycols. In the chapter upon silicon some very interesting original views are presented concerning the formulæ of silicates and the method of computing them. We believe that this is the first text-book in which all the great theories of modern chemistry are systematically, clearly, and logically presented. At the outset certain broad principles are laid down with reference to the nature of atoms and their relations to the chemical and physical forces, and upon these principles, as a foundation, the phenomena of chemical science are built up into a symmetrical and imposing superstructure. The great strength of the book, however, is in the vast array of numerical problems by which the principles are illustrated. They test the knowledge of the student in every possible way, and greatly increase his power of applying it. The book is no ordinary one, but it is to be placed with those distinguished few like "Fresenius' Anaysis," "Herschel's Astronomy" and "Dana's Geology," which mark an era in the history of instruction in the sciences to which they relate.—*Journal of the Franklin Institute.*

La Fortification Improvise. Par A. Brialmont, Colonel d'Etat Major. Bruxelles: Micquart. 1870. 8vo., plates. For sale by Van Nostrand.

This thoroughly practical and instructive little work, by Colonel Brialmont, well known to military students as an author, and as one of the ablest and best-informed officers in the scientific corps of the Belgian army, would be well worth translating into English for the benefit of our volunteers, if not for commissioned and non-commissioned officers of the line.

It not only treats—as practically as even a contractor for earth work could desire—of the formation of field-works, but also with lucidity, and aided by many well-chosen examples, taken from military history, of the tactical and strategic capabilities and relations of field-works, and how nature and natural features are to be made to aid the shovel, and these the rifle and the sword.

Les Houillieres en 1869. Par Amedee Burat, Ingenieur, etc., etc. Paris: Baudry. 1870. 1 vol. 8vo, and 1 atlas folio. For sale by Van Nostrand.

M. Burat, known to most persons engaged in coal mining by his previous able and voluminous works, descriptive of the great French coal basins, and of their colliery workings, is the secretary of the Committee of French Collieries—or, as we might say, French coal owners—and as such is the author and editor of this above-named work. Three eminent members of this committee have been removed by the hand of death during the past year, and the volume, which is dedicated by its author to their memory, commences with three interesting memoirs of the lives and careers of the deceased members, MM. Jean de Bret, De Cheppe, and S. Dubois.

The first thirty-five pages following are occupied with a subject second to none in importance to the coal industry of France, as it equally is so to that of every sort of industry in every country, namely, that of *strikes*. It is one of the most remarkable, as well as one of the most novel features in the actual social aspect of the Continent, that strikes (*grèves*), which for a long time seemed almost confined to ourselves, and to be the outcome of our rich and fluctuating profits, our ignorance, and more or less ill-feelings on the part both of employed and employers, and of our freedom, have got firmly rooted amongst the wage recipients of the Continent; and latterly appear to be by these conducted with a degree of acrimony, political admixture, and violence, which throw our own like disgracing and disordering events, quite into shadow.

We have here the circumstances and details, as well as the final consequences, told of five or six of these great French colliery strikes. We shall not attempt to analyse these in so brief a notice as we can here afford space for. The second chapter, which in some respects is the *piece de resistance* of the book, consists of clear descriptions referring to the atlas of plates of some of the most recent and noteworthy pit-work and machinery constructed for French collieries. We have here the pit-work of Providence Pit, in the Pas de Calais. The direct-acting pumping engine of Kladno, in Bohemia; the great pumping engine of Mainbourg, of 1,000-horse power; the new pumping engine for the Saint Laurent Pit at Creusot, in which there are several novelties, as well as a decided improvement in the arrangement of the ponderous balance bobs—based on purely scientific considerations; and, lastly, a detailed account of what will probably ere long be pronounced the most wonderful water-pressure engine in the world, namely, that—by this time most likely at work—under ground in the pit of Montceau les Mines. It has been designed by M. Audemar, the mechanical engineer of the colliery, and is to raise water under a pressure of about 600 metres of head. The remainder of this volume consists of the statistics of French coal output, compared with that of other States, for the year 1869; and of the legislative Acts and other public documents bearing upon colliery interests in France for the same period.—*The Engineer.*

Die Einzeit der Erde. Von Alex. Braun. Berlin. 1870. Pamphlet. For sale by D. Van Nostrand.

Is one of a series of popular but good lectures on many various subjects of a philosophical or scientific class, which are published in a serial form by Virchou and Holtzendorff, of Berlin, and to which—partly on the score of merit as to the leading notions of the publication, partly on those of its cheapness and good type, though that is the eye-straining Gothic text—the gold medal was awarded at the Amsterdam Exhibition of last year. The present is the third series of this work, and comprises subjects as various and diverse as "Machiavelli," "The Exchange and Speculation," "Hospitals and Lazzarettes," "African Discovery," "Scientific Botany," etc. The part we here notice records a lecture delivered at the hall of the Singing Academy of Berlin by Herr H. Braun, with subsequent additions by the author. It is a good sparkling account of the most advanced in geological speculations, but fails wholly in pointing out the excessively small basis upon which a large part of the glacial epoch, and all that thereto belongs, has been built up, or in separating, as to it, the true from the false.

Handbuch der Edelsteinkunde. Von Dr. Albrecht Schrauf. 1 vol. 8 vo, with 43 woodcuts. Vienna. 1869. For sale by D. Van Nostrand.

This is as complete and clear an account of the natural position of our earth, of the physical and chemical properties, and of the characteristics, important to the traveller, of all the mineral substances used as personal ornaments, and commonly called precious stones, as we have anywhere seen.

Dr. Schrauf, who is a lecturer on mineralogy in the University of Vienna, and keeper of the royal mineral cabinet, has condensed a vast mass of information, given it accurately, and given abundant references to his authorities for much curious historical information scattered through its pages, which embrace every ornamental stone from diamond to quartz, excluding all such as are *alone* used for architectural decorations, such as alabasters, jaspers, marbles, etc.—*The Engineer.*

First Lessons in Inorganic Chemistry. By T. Ward, F. C. S., etc. Manchester: John Heywood. London: Simpkin, Marshall & Co. 286 pages.

There is already more than a superabundance of small text-books and manuals on chemistry; and it is a matter for wonder that, while there is no lack of really excellent books for young pupils,

so many authors rush into print, imagining that they can improve upon what exists, and evidently forgetting "*Comment fait on des livres? Avec des livres.*" Let us briefly glance at the contents of this little volume. It partakes, in its arrangement, of two excellent works—viz., Stöckhardt's well-known book; and the small volume written by Professor Roscoe. We are sorry to be compelled to say that Mr. Ward's book is inferior to each of these, individually, as it is deficient in that lucid and precise clearness of exposition and soundness of definition which so eminently characterize the two works just alluded to. While we thus express our opinion, we must in all fairness also say that, as far as we have perused Mr. Ward's book we have not found therein any heteredox or incorrect statements. The book is well got up, is provided with wood-cuts, and contains some very useful tables relating to weights and measures, thermometer degrees, and a copious index. There is also added a chapter on qualitative analysis, which is, however, too brief to be of much use.—*Chemical News.*

The Production of Iron and Steel in its Economic and Social Relations. By Abram S. Hewitt, U. S. Commissioner.

The immense importance of the industry of which this report treats will lead to its being more widely read than the reports of either of the other Commissions.

The information contained in it is of an exceedingly valuable kind; the statistical matter is presented in a compact form, and the conclusions drawn by the thoroughly practical mind of the author are given with admirable vigor and conciseness. The second section of the report is devoted to Bessemer steel, and was prepared by Mr. Slade.

The Progress and Condition of Several Departments of Industrial Chemistry. By J. Lawrence Smith, U. S. Commissioner to the Paris Exposition. Washington: Government Printing Office.

The separate chapters of this report taken in their order treat of: 1st. Sulphuric Acid Manufacture. 2d. Soda and the Salts of Soda. 3d. Potash and its Compounds. 4th. Ammonia, Baryta, Magnesia, and Alumina. 5th. Chlorine, Fluorine, Manganese, and Carbonic Acid. 6th. Industrial Production of Oxygen, Hydrogen, and other elements. 7th. Gas Manufacture. 8. Stearic Acid Industry.

The report is illustrated by seven folding plates.

Report upon Steam Engineering as illustrated by the Paris Universal Exposition, 1867. By Wm. S. Anchingloss. Washington: Government Printing Office.

The several divisions of this valuable report treat respectively of Railway Engineering, Portable Engines, Cranes, &c.; Steam Generators, Stationary Engines, and Marine Engines.

The report covers 72 pages of well-condensed matter, illustrated by 20 woodcuts and five folding plates.

Royal Commission on Water Supply. 1. Report of the Commissioners. 2. Minutes of Evidence before the Commissioners. 3. Appendix to Minutes of Evidence. Presented to both houses of Parliament by command of Her Majesty. London: Eyre & Spottiswood.

The above volumes, three in number, contain many finely executed maps. As all the topics bearing on Water Supply, Distribution and Purification are thoroughly discussed by the Commission, the report cannot fail to be valuable to Engineers interested in this branch of professional labor.

First Annual Report of the Geological Survey of Indiana, made during the year 1869. By E. T. Cox, State Geologist. Indianapolis: A. H. Connor, State Printer. For sale by Van Nostrand.

This survey includes the counties of Clay, Greene, Fountain, Warren, Franklin and Vermillion, and includes a portion of that coal area known as the Great Illinois Coal Field.

The maps which accompany the Report represent Clay, Greene and Vermillion counties. The Report dwells chiefly upon the economic geology of the area embraced in this first survey.

Comparison of the Dimensions of American Blast Furnaces. By T. Eggleston, Jr., Professor of Mineralogy and Metallurgy, School of Mines, Columbia College. For sale by Van Nostrand.

This is a pamphlet of four leaves only, containing in tabulated form the dimensions of the various parts of blast furnaces in the different States of the Union.

The statistics were collected by Professor Eggleston, who addressed circulars to iron manufacturers soliciting this kind of information.

The New Elements of Hand-Railing, in concise problems, calculated to bring this most useful science within the reach of every capacity. By Robert Riddell. Illustrated with 40 plates. Philadelphia: Claxton, Remsen and Haffelfinger.

This book is for the practical builder only. The directions for laying out work in this branch of labor are concisely given, and the plates seem to be all that can be necessary.

Notice sur l'Eclairage aux huiles Minerales. Par Edmond Colin. Conductor des Ponts et Chaussées attaché au service des Phares. Paris: Dunod.

A work of 120 pages, with three large plates, illustrating the preparation and use of petroleum for illuminating purposes, and especially the different forms of burners which are adapted to lighthouses.

Fermeture Cylindro-Prismatique. De F. Krupp. Pour les cannons de gros calibre. Paris: Libraire Militaire.

A pamphlet of 13 pages only; the text being devoted to the description of the five plates. The work is of undoubted value to all who are interested in heavy ordnance.

Formules Approximative de Construction Navale. Par J. A. Normand. Paris: Arthur Bertrand.

A thick quarto pamphlet, illustrated by numerous wood-cuts, and containing nine large plates.

De la Methode a Posteriore Experimentale, et de la Generalite de ses Applications. Par M. E. Chevreul. Paris: Dunod.

MISCELLANEOUS.

Shading and Tinting Drawings.—From a correspondent's letter from California, we take the following valuable hint to draughtsmen :

"Every engineer has felt the difficulty of shading or tinting mechanical drawings by the usual methods. A very perfect tint may be readily obtained as follows :

"Take a small piece of fine wire cloth, about fourteen openings per inch, and a short, stiff brush. Hold the cloth over the place to be tinted or shaded and rub the brush, slightly filled with the tint, quickly across it. By continuing this process a short time a tint is formed from the minute drops which fly off from the brush by the rubbing on the wire. Thus parts of the drawings which are not to be tinted with the first color can be covered with pieces of paper, pinned to it with fine needle points, or held by paper weights ; and different depths of the same tint may be had by covering the parts in succession with pieces of blank paper. The effect of drawings finished in this way is similar to that of a fine lithograph."

White Brass.—A metal bearing the above name —which is correctly applied—has recently been brought under our notice, and promises to play an important part in its application to the bearings of machinery and for other similar purposes, if, indeed, it does not do so already. This metal is the invention of Mr. P. M. Parsons, and is manufactured by him at the Thames Foundry, East Greenwich. Although somewhat similar in appearance to some of the alloys known as white metal, it nevertheless differs from them most materially in other respects, inasmuch as it is harder, stronger, and sonorous. It is, in fact, as its name indicates, a species of brass, and behaves in a similar manner to that metal under the tool when bored or turned. It does not clog the file, and is susceptible of a very high polish ; at the same time its fusing point is lower than that of ordinary brass, and it can be melted in an iron ladle over an ordinary fire. These special features render the metal valuable for fitting up machinery where first cost has to be kept down, as it can be run in place for bearings, or bushes, thus avoiding the expense of fitting or boring. It can also be cast in metal moulds, or even in sand and loam, like ordinary gun-metal. Although this new metal is not very generally known, we find it to have been in use for some years past in various engine works and on several of our leading railways, where it has proved itself particularly suitable for the bearings of engines and carriages, and the wearing parts of machinery generally. Having indicated some points of resemblance existing between white brass and ordinary brass, let us now turn to the points of difference, which are very marked. Compared with gun-metal or ordinary brass, white brass is the cheapest, whilst at the same time its durability is greatly in excess of either of those metals. This latter point has been established by a series of carefully conducted experiments on the Great Northern Railway, made with carriages running in the express train between London and Edinburgh, the axles being fitted with ordinary brass bearings at one end, and white brass bearings at the other. These experiments were instituted by Mr. Sturrock, and they form the subject of a report from that gentleman, and which is now before us.

According to this report, which is dated the 20th May, 1862, it appears that two white brass bearings, fitted under a break van, lost only 2 ounces in weight in running 19,400 miles. Two ordinary brass bearings, fitted under the other end of the same van, and which travelled the same distance, lost 2 lbs. 4 oz. In another case a third-class carriage was fitted up in a similar manner, and ran 20,000 miles. Here the white metal bearings lost only $2\frac{1}{2}$ oz., whilst the ordinary brass bearings lost 1 lb. 6 oz. In another third-class carriage similarly fitted, the diminution in the white metal bearings was $2\frac{1}{2}$ oz., whilst in the ordinary brass bearings it was 1 lb. 12 oz. in running 20,000 miles. The bearings ran perfectly cool, and were lubricated with oil. In July, 1864, four white brass bearings were taken from a brake van which had run 64,712 miles. Mr. Sturrock reports that the bearings were still in very good order, and but little worn. After this important testimony to the value of this metal, little more, we think, can be added than that it has proved itself equally successful in bearings for general purposes. We cannot find that such a thing as a hot axle has ever been heard of where it has been used as a bearing ; in fact, it seems to possess the peculiar property of lubricating itself to a certain extent when the oil or grease fails. This much is certain, that when it was adopted on the Great Northern Railway, the stoppage of the long express train from London to Edinburgh from hot axles entirely ceased, although stoppages from this cause had previously been of constant occurrence. It would seem to us that the knowledge of such facts as we have here before us, is all that is required to render the use of white brass general.

The Best Form of Chopping-Axes.—If nothing were required of an axe more than to simply sever the grain of wood by cutting the fibres in twain, the form of bit to operate with the greatest efficiency would be that of a thin tapering wedge. But since the bit has another office to perform, namely, the removal of the chips, that part of the instrument near the cutting edge must be ground to the most effective form for "chipping well." After the bit of a chopping-axe has been thrust into wood one or two inches, the cutting edge can not be forced the same distance further, at the next blow, unless the chip that has been cut off be lifted or thrown out of the kerf. Were the bit of a chopping-axe ground off true, like an iron wedge, the chopper would be obliged to exert as much strength to withdraw his axe from the wood as was required to drive the edge into the timber. For this reason, the bit at one and two inches from the cutting edge is made thicker midway between the front and rear side edges, for the purpose of splitting every chip that is cut off. Then the two flat sides of the blade, from the cutting edge toward the eye, instead of being dressed to a true taper, are ground somewhat circular, so as to be of the most efficient form to raise the chip as fast as the wood is cut off. These suggestions furnish a philosophical reason for making the bits of chopping-axes of the peculiar form which they receive at the hands of the manufacturer.

It is not practicable to convey to the reader a correct idea of the most efficient form of a chopping-axe, except by an oral explanation with an axe in hand, to illustrate points that can not be committed to paper. An intelligent chopper, if he will exercise a little thought on the subject, will per-

ceive at a glance, what form of bit will enter the wood deepest, and at the same time lift the outside chip from the kerf when the instrument is wielded with a given force.

Another important point in the form of the cutting edge is its curvature from the front to the rear corner. When the bit at the cutting edge is made almost straight from corner to corner, a chopper will be able to chop faster, and make less "mince meat" of small chips, and leave the ends of the logs smoother, than if the cutting edge were made of a more circular form. Most axes that are now manufactured have almost no corners at the cutting edge, the bit being formed with as short a curve as an old-fashioned chopping-knife—nearly circular. When the bit of an axe is made of such a form, it will seem to enter the timber further, at a given blow, than if the cutting-edge were nearly straight; and the central portion is actually driven deeper into the timber than if the cutting edge were nearly straight. But a portion of the cut is really of no account, as the outer chip was not lifted.

When scoring timber, it is of eminent importance that the cutting edge of the axe should be nearly straight from corner to corner. Otherwise, the face of the hewed stick will appear badly hacked with deep cuts beyond the line, which will always be the case when scorers employ axes with circular edges. Many a skilful scorer has used an old axe with the corners ground off, and has exercised great skill in endeavoring to cut only to the line. But after the hewer had dressed off the side of a stick, splitting the line with his broad-axe, the work of the skilful scorer would then show that the scoring had been done in a very unsatisfactory manner, simply because the form of the cutting edge of the axe was not correct.—*Manufacturer and Builder.*

MINING TOOLS FROM SINAI.—At a recent meeting of the Manchester Literary and Philosophical Society, Mr. William Boyd Dawkins, F. R. S., exhibited some old mining tools, brought over by Mr. Bauerman from the turquoise mines of the promontory of Sinai, consisting of a stone hammer and rude splinters of flint. The turquoises occur in a bed of a quartzose mottled sandstone in Wady Sidreh and Wady Maghara, in joints running for the most part north and south. They were worked, according to the evidence of the hieroglyphic inscriptions on the rock, by the Egyptians from the third to the thirteenth of the dynasties mentioned by Manetho. In and around the workings there are still the tools with which they were carried on. Innumerable splinters of flint, with their points blunted and rounded by use; stone hammers, some of which are broken; and round pebbles with a concavity on either side caused by the friction of the thumb and finger charged with particles of sand, and segments of small wooden cylinders, lie together. The flint flakes exactly coincide with the grooves in the rock made in the excavation, and evidently have been blunted by such use. The fragments of wooden cylinders are believed by Mr. Bauerman to have been portions of the sockets into which the flakes were fitted. The round pebbles were probably used for driving the rude chisel formed by the flint inserted into the wooden socket, while the large stone hammers were used for breaking up the rock. There was no evidence that metal of any kind was used in the work. Mr. Bauerman also satisfied himself that the hieroglyphs were cut with implements similar to those used in the mining. This discovery is very important, because it opens up the question as to what tools the Egyptians used in working their wonderful monuments of granite and syenite. If it were worth their while to conduct turquoise mining with flint flakes in the Sinaitic promontory, and if they used the same tools in the hieroglyphs that fix the date of these mines—and of this there can be no reasonable doubt—it is very probable that they employed the same means for the same end elsewhere, and that, to say the least, a part of their marvellously minute sculpture in Egypt has also been wrought with flint. There is no evidence that they were acquainted with the use of steel. Iron and bronze are not hard enough for the purpose. The minute and delicate sculpture left behind by the Mexicans, which can be proved to have been worked with stone tools, adds to the probability of this view.—*Mechanics' Magazine.*

ROUGET'S FIXATIVE PROCESS.—In the month of March of last year Prof. Rouget, one of the Masters in the Government Schools of Paris, made a discovery, which in its effects will be invaluable to artists and the art world in general; indeed, it appears to us that this useful invention requires only to be known to be at once fully appreciated, and we gladly take this opportunity of mentioning it to our various readers. It is a rapid and apparently perfectly safe method of fixing chalk, charcoal, crayon or pencil drawings, by means of a particular fluid blown through a glass siphon in the form of a fine spray, on to the material to be fixed. The paper on which the drawing is made is not injured by the fluid; on the contrary, it is preserved by it—in fact, one of the great uses of this fixative process is supposed to be the preserving of the paper and color of water color or other drawings from decay. The apparatus is in itself of a very simple character, a child might learn to use it, and it is likewise very portable. The process has been warmly taken up by many distinguished French painters, architects, and draughtsmen; amongst them, we may mention Gerome, Cabanel, Villems, Gleyre, Viollet-le-Duc, and Gustave Doré; it has also been used by some well-known artists in this country, and they have expressed themselves well satisfied with the results. It was tried this summer on a crayon sketch of a sunset, and the glowing colors were not in the least injured. This is an example of the undoubted benefit of this process to the painter, for with its aid he may rapidly draw in sunset effects, with that most rapid of mediums, colored crayons, and keep them by him as studies for ever, as bright and uninjured as when first executed. There is another agreeable quality in this process: when the drawing has been fixed, is is quite easy to work upon it again and again, providing only that the parts worked upon be finally blown over with the spray when the drawing is quite finished. Architects will find this apparatus most useful in fixing their rough pencil sketches and more elaborate drawings of architectural details. The very simple rules for using Prof. Rouget's process are sent with it, packed altogether in a neat little box. The London agents for the apparatus are Messrs. Corbière, 30 Cannon street.—*The Building News.*

AN ASBESTOS AIR FILTER—MANGANESE AND SOME ALLOYS OF IT—RESULTS OF CARBONIZING WOOD

IN VARIOUS VAPORS.—A very good suggestion for an air filter, equally applicable for a ventilator or a respirator, is made by M. Woestyn, who proposes to place in a ventilating shaft a bag of asbestos. This, like cotton, will arrest any solid particles floating in the air, and when much soiled, the asbestos can be removed and made white hot, by which all organic matters will be destroyed, and it may then be put back in the shaft again. For respirators, asbestos would be far preferable to the cotton wool proposed by Dr. Tyndall. It would not hold moisture like the wool, and would at the same time be most efficacious as a filter; and made so that the asbestos could be easily removed to be burnt and put back again, they might come into use and be highly recommended. There would be obvious difficulties in the way of effectually filtering the air admitted to a large building, but we agree with M. Dumas in considering that the suggestion of M. Woestyn is worthy of serious attention.

Manganese, we fear, will never be a cheap metal, and alone would seem to be susceptible of no useful application; but we learn from the researches of M. Valenciennes that it forms very beautiful and useful alloys with copper. One in particular, containing only 15 per cent. of manganese, is almost white, and in many of its properties greatly resembles steel. Other compounds form, we are told, superb bronzes. How far these may be capable of replacing our ordinary bronze it would be premature to speculate in the present undeveloped state of the industry of manganese. The same metallurgist we have mentioned above has procured pure cobalt, which seems to be a metal that may some day be usefully applied.

People sometimes do odd things and arrive at strange and unexpected results. What M. Sidot was driving at when he carbonized wood in the vapor of sulphide of carbon we cannot imagine; but it ended in his obtaining charcoal, which, when struck, is as sonorous as a piece of metal. He then got a bell turned in wood, carbonized it in the same way, and has an instrument which gives a sound like that of a silver bell. The carbonization is only superficial, and possibly the bell may not be very brittle, as it certainly would be if it were complete. Besides sulphide of carbon, the author calcined wood in the vapor of wood spirit, and so obtained a fibrous coke of silky whiteness. This is a very curious result; white coke is a novelty, and it would be interesting to know for certain what does happen when wood is heated to a carbonizing temperature in the vapor of wood spirit.—*Mechanics' Magazine.*

TIN IN CALIFORNIA.—The Philadelphia "Railroad and Mining Register" says: It has long been a desideratum to find this metal in America. In the Old World and in ancient times the alloy of this metal with copper supplied the place of iron and steel. Egypt probably owed to it the erection of its mighty edifices, not only before, but long after the communication was opened between the valley of the Nile and the highlands of Armenia and Persia. Even after the consolidation and extension of the Roman Empire in the iron producing regions of Asia, Spain and Britain, the Roman legions were armed with offensive weapons of iron, but with defensive armor of bronze. England owed her first important influence upon the civilized world to the tin mines of Cornwall. Where the Peruvians got their copper-tin alloy from is not well known, but they had hit upon its proper constitution before the appearance of their Spanish conquerors. Tin was an American mineral. Nevertheless, it was found impossible to open mines of it anywhere this side of the Atlantic, worth the pains. The discovery of a few thin veins by Dr. Jackson, in the White Mountains, and of crystals of tin ore here and there in various other parts of the United States, was heralded with great enthusiasm, but resulted in no benefit to the arts. Within a year or two traces of tin discovered in Missouri gave rise to much speculation, some of it of a rather dishonorable character. Ores of tin from that State proved to contain, either the smallest percentage possible, or none at all. But at last some genuine and rich tin ores have come to light, and are authenticated by the highest authority we have at hand, as the following letter from Dr. A. R. Roessler, the learned and efficient mineralogist of the United States General Land Office, Cabinet of Practical Geology and Mining, at the Capital, to the editor of the "Franklin Institute Journal," will show:

SIR,—It will be remembered that an exposition of the agricultural, manufacturing and mineral resources of California was held last year at San Francisco, at which were exhibited the unmistakable evidence of the existence of the metal tin in California. Sacks of ore, bars of tin plate, of the heaviest quality, and utensils of every sort for domestic use which were manufactured from it, were there collected. There were many who doubted and shook their heads at this display of a long desired but unusual manifestation of riches. The days of humbug were not yet over. Gold and silver, quicksilver and platinum, and many other more common metals in any quantity, they should believe in; but the metal tin, so valuable and found in so few localities in the world, was a demand on their credulity not to be honored. This uncertainty has become, not a dead, but a living certainty. Additional information and additional specimens of ore have been forwarded to this office, and an average sample of the same has been submitted for analysis to the able and distinguished chemist and mineralogist, Dr. F. A. Genth, who reports that it contains 13.37 per cent. of tin. The black mineral in the ore is tourmaline (it contains boracic acid) and the brownish red is the casiterite. It is a highly interesting occurrence, and the yield of tin is almost twice as much as the usual working ores of the tin mines of Cornwall, England. The property is said to consist of 50,000 acres of mining lands, and over 20 openings have been effected, from all of which the ore is extracted. The finding of this important metal in California may be regarded as the last crowning act which was required to place California in advance of all the world for mineral wealth.

Respectfully,

A. R. ROESSLER.

—*Iron Age.*

A very easy way of detecting logwood color in wine has been published in France, which, if good for anything, will be useful in discovering the adulteration of port. We have only to moisten a strip of paper with a strong solution of neutral acetate of copper, and dip it into the suspected vinous fluid, which, if it contains logwood, will give a blue color to the paper. If, however, the color of the wine be the natural product of the grape, the paper changes to a gray shade.

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A GLANCE AT AERONAUTICAL SCIENCE.*

By MR. W. CLARE.

From "The Mechanics' Magazine."

The reading of the Aeronautical Society's report for the past year is a task somewhat tinged with a shade of the melancholy when we consider how little has really been done in that time—not one new theory has been advanced, not one experiment of value made. It is at all times pleasant to feel that we are moving forwards in the track of any scientific discovery; indeed, we all of us have a great objection to a retrograde motion, while many dislike progressing (after the manner of a crab) in a sideways fashion, or, in other words, studying the collateral branches of an incomplete science. But when we have come to the end of our tether in a forward direction, stuck in the mud as it were, or have wandered into one of the many and devious paths of error, it becomes us, I think, the rather to retrace our steps, and as we retire carefully to note the ground over which we pass, with a view of discovering where we first turned aside from the right path, and, instead of helplessly sticking in the mud and merely looking about us, to go back and endeavor to find some way of successfully passing over, or going round, the discouraging slough.

Now this is the scheme, the adoption of which I think would be beneficial to the at present infantile science of aeronautics, and my object this evening is to try and gently lead you back to your place of starting and there to leave you, hoping that with the experience already gained you may be more successful in your next journey towards the solution of those mysteries which now so closely enwrap the almost chimeric science of the theory and practice of flight.

The method by means of which I shall hope to attain this object will be to endeavor to point out, as far as I am able, a few of the many paths of error, and to try and explain the nature of that mud in which we seem so firmly embedded. The few sentences I am about to read are, for the most part, founded upon the assumption that the majority of those present this evening have carefully perused the four interesting reports of the proceedings of the Society issued by it.

History furnishes us with many interesting proofs that artificial flight must, in a greater or less degree, have occupied the minds of the learned in every age. The Jews had their cherubim, carried out, moreover, under divine instruction; the Assyrians have left us their winged bulls, the Greeks their sphinxes, while Roman writers tell us how the mythical personage Dædalus flew across the Ægean sea, and this nation has bequeathed to us various reliefs illustrative of what appear

* Paper read at a meeting of the Aeronautical Society, in the Society of Arts, June 3, 1870.

to be well-proportioned wings, which have possibly played some part in the manufacture of the angel of the painter. The fact that the problem of flight has been present to the minds of so many myriads of the human race displays to us the magnitude of the enterprise upon which we have entered, and teaches us how necessary it is to labor with the strength of unity, and to be careful to extend our researches in a right direction. "Onwards and *upwards*" must be our motto. The ancients seem to have had one idea of flight only, but to us the subject seems naturally to divide itself into two branches, namely, that of aerial ascent, locomotion, and navigation by means of power, and individual manual flight ; this latter appears to me the purer branch of the science, one more worthy our consideration, and the one in which nature seems the more inclined to help us. The bird has been greatly upheld as a model teaching us how to fly, though there is no reason why a bird should teach us practically how to fly any more than a fish has taught us how to swim or how to propel our vessels, but they have hitherto materially assisted the pursuit of the theory of flight, and doubtless may yet somewhat help us in our investigations of its practice. Man had to learn to swim, he has yet to learn to fly. Flight is little else than swimming, though in a medium far less dense than that of water, and a corresponding increase in speed, combined with wings sufficiently long to permit us to decrease this speed to a practical limit, seems only required to enable us to float as calmly in the unyielding air as we now do in water.

This remark paves the way to the first error, and a very common one, to which I desire to direct your notice for a few moments, which is, that heavy wings or heavy machinery must necessarily retard or render impossible flight. Now, I imagine that if, when the "Great Eastern" was building, anyone had been absurd enough to say, "This ship is so heavy it can never float," we should have answered, "Nonsense, weight is nothing, it is a question of displacement only." There is little theoretical difference between flight in water and flight in air ; the difference is a practical and mechanical one, and provided our wings or machinery displace sufficient air in proportion to their weight we need have no fear of making them too heavy. This proportion, however, varies, nature teaching us that the amount of wing surface in proportion to weight decreases as the weight increases. It is hardly necessary here to remind you that ratios do seem to relatively exist between weight, power, and surface.

The second part of error to which I wish to call your attention is the still too prevalent, though happily almost exploded idea, that air cells help, except in a very limited degree, the flight of birds. Dr. Wenham has, I believe, already attracted your attention to the fallacy of this theory (for it has never gone beyond theory), and allow me to ask, Why air cells should assist a bird to rise in the air? If, as is reasonable to suppose, these cells are fitted with an extremely rare gas, a power of buoyancy would of course be the result ; but what a power! under the most favorable circumstances bearing something like the enormous rate of $\frac{1}{4}$ per cent. (.025) to the weight. Were, however, a bird thus buoyed up, as many still suppose, flight would be rendered impossible by that very buoyancy, as impossible as the flight of a balloon—by flight I mean of course controllable flight. This air cell business is by far the weakest argument yet brought forward.

Another common error seems to be the notion that models are such a necessary and essential help to the object of this Society. The province of a model is to explain an invention to others after it has been made, and not to assist the inventor. In every great invention they have (except within very restricted limits) been found to be almost useless, and most of our valuable discoveries have been made and carried out without their aid. Watt's first condensing engine had a cylinder of 18 in. diameter, which is, I believe, somewhat above the average size of the cylinders now in general use, and I imagine that if would-be inventors of artificial flight would, like Watt, first mature their theories with no aid from models, save those of a most elementary description, there would be but little difficulty, except with regard to practical details, in afterwards carrying out those theories. The model is a rock upon which many an inventor has been broken up ; if a project succeeds in the form of a model it often fails in after practice, and *vice versâ*. The

impenetrable stupidity of model makers frequently renders models worse than useless, proved by the fact that inventors rarely employ the same modellist twice.

Another devious path is the almost general hankering after steam in some form or other, which has existence in the minds of aeronautical people. I fear the steam-engine is far too wasteful a machine ever to suit the requirements of aerial navigation, and when we consider that in a good condensing double cylinder expansive steam-engine we waste (I speak from memory only) about 90 per cent. of coal, and that a bird uses his power with, I suppose, no appreciable waste, the comparison becomes very unsatisfactory and a very unpleasing one to dwell upon. Nature, however, teaches us that the power necessary for the flight of a bird is after all but small (the horse power of a pelican being generously estimated at 1-11th by Mr. Wenham, I believe), but it is used in a manner far more economical than machinery is ever likely to effect. Birds feel the air and seem toguide their flight by nervous sensation; machinery, I fear will never accomplish this, though man undoubtedly will. Dr. Smyth, in his experiments with the wings of a pigeon dried in an extended position, found that, however cleverly and closely he imitated the motions of a pigeon by means of a spring, he could raise no weight except very occasionally, and then by jerks; which proves that great power is not required so much as a successful manipulation of a small power.

Will it be considered superfluous here to remind you that, though birds of the struthious or ostrich order do not fly, weight is by no means the cause of their failure? You will perhaps allow me to quote in a parenthesis the quaint old naturalist Buffon's contrary opinion on this subject. He says: "The ostrich is generally considered as the largest of birds, but its size serves to deprive it of the principal excellence of this class of animal—the power of flying. The medium weight of this bird may be estimated at 75 or 80 lbs., a weight which would require an immense power of wing to elevate into the atmosphere, and hence all those of the feathered kind which approach to the size of the ostrich, such as the cassowary, the dodo, neither possess nor can possess the faculty of flight." The drift of all this preamble and quotation is that I wish to ask you why and how it is that these birds are not constructed for flight. There doubtless is some wise reason, but I have never yet heard an explanation which has in any way satisfied me.

Another query it would be well to have definitely answered is this: We frequently see birds, especially swallows, flying at an angle at times as great as 45 deg. to the horizon. By what means do they attain this position, how maintain it, and how return from it to the horizontal? It will be useful to know, because when man flies, as he undoubtedly soon will do, he will require similar steering, balancing, or tail apparatus. We must endeavor also in our investigations to forget the very existence of such a thing as a balloon, which is at best but a meteorological instrument, though a most useful, and, when in the skilful hands of Mr. Glaisher or some few others, a very scientific one. It is altogether foreign to the ultimate aim of this Society. We must study and put into practice nature, and, to a certain extent, leave art and chemistry alone. One more suggestion here too. As we can only hope to build up future successes on past failures, I think all failures ought to be discussed and analyzed; for instance (though the remark applies to others), Mr. Spencer was going to fly at the Crystal Palace in 1868; may I ask, with every apology for my abruptness, why he did not?

Now let us consider the nature of the mud in which I have said we are stuck. The cause of our stand-still, briefly stated, seems to be this: men do not consider the subject of "aerostation" or "aviation" to be a real science, but bring forward wild, impracticable, unmechanical, and unmathematical schemes, wasting the time of the Society, and causing us to be looked upon as a laughing stock by an incredulous and sceptical public.

To explain what I mean I need only refer you to the last meeting, July 14, 1869, when, after a very learned dissertation on the breaking strain of brass, a gentleman (Mr. R. Sheward), though I do not wish it to be understood that I am making an exclusive raid upon this gentleman, explained to us a machine caused to rise by the principle of exhaustion, and showed us the small steam-engine and exhauster neatly stowed away in a kind of small boat. Now had this gentleman calculated (or got some one else to do it for

him) the power required to diminish the air above his machine sufficiently to allow of only a very moderate speed, he would for obvious reasons have found it enormous; indeed, I doubt if his engine would even find standing room on his aeroplane. I have made a rough calculation of the probable power required (the plane being 60 ft. by 40 ft.), and find it would be at a very moderate computation from 200 to 300-horse power.

Now, we ought and must try to avoid these flights of fancy (which seem to be the only methods of flying understood by many) and deal with the solid and tangible facts at our disposal, which facts can be greatly amplified by more careful, mathematical, scientific, and practical investigation and research than has hitherto been made into the method of flight adopted by birds, the bat, and insects, the power they respectively employ, and the sustaining surface they severally have in proportion to their weight, together with, if possible, their speeds. We shall then, knowing more thoroughly the conditions and requisites of flight, be in a position the better to contend with those difficulties which have hitherto been our conquerors. But while pursuing what I have, perhaps, erroneously called the theory of flight, let us not forget that artificial flight is more a practical question than a theoretical one, and as such must be practically and experimentally studied by practical and experimental men.

The questions I asked of you, and the inquiries I made a sentence or two back, will, I think, bear far more study than has at present been bestowed upon them, though I am aware that they have been to a limited extent answered before, M. de Lucy having been the chief contributor. The facts deducible from these somewhat crude answers amount to this, that we have no doubt whatever that man can be made a flying animal, no doubt that he will eventually perch on Stafford House, but that there are some rather awkward, though only practical difficulties in the manufacture of the requisite apparatus. Few will, I think, in the present day (no one here I hope) venture to dispute that man, the lord of creation, is capable of flying; such doubt would be little short of a reproach on his Maker; he can walk upstairs, though in so doing he uses his power in a most wasteful and unmechanical way, and surely he can mount upon air, which, properly manipulated, is as solid as any stair; he must, however, first remove another great stumbling-block.

Man has at present, owing to his ignorance and clumsiness, no means of safely getting up the initial velocity necessary to render the air a solid support (I am here supposing that he has surmounted the slight difficulty I spoke of relative to making his wings). To obtain this velocity he can of course insure his life and start from some eminence; but this is considered by many to be an "eminently" dangerous experiment. Perhaps it is; I think it so myself, and I will, therefore, with your kind permission, before I conclude, briefly lay before you an undeveloped idea of mine, having in view the reduction of this danger, which, though rough, is one which perhaps may assist, in however limited a degree, the object for which we have met.

A word here in passing. No one has yet succeeded in flying any distance, and for this sole and simple reason, no one has yet constructed the necessary apparatus practically in accordance with the theories already advanced in the science. This is a broad statement to make, and one which will doubtless encounter a good deal of disapprobation and dissent; but I honestly believe it to be the truth, and my aim now is to endeavor to point out a safe and simple means of practically experimenting on the requisites of flight. In Germany they teach swimming by suspending the learner from a rope; in England we must teach flying in the same manner, and I propose turning our aspiring (soon perhaps perspiring) experimenter into a rotatory pendulum, like the governor ball of a steam-engine. To make myself more intelligible, I will now proceed to explain my proposal. The rod of my rotatory pendulum is a rope, as long as can conveniently be obtained, a captive balloon even being used as the centre if requisite, and the bob or governor ball is represented by the experimenter and his apparatus. In accordance with the idea expressed in an early part of this paper, I would at once fit out my man with the theoretical length of wing (open to discussion perhaps). Not minding the necessary weight, which should, however, be as little as possible,

a man, like a bird, should be able to spread his wings, as the experimenter will lift himself on his wings and not drag them after him. The wing is not a lever, or if it is, is one of a very doubtful order, having a fulcrum for the whole of its length. He should, for various reasons, work them mainly with his legs, leaving his arms and hands free for guidance and balancing. They would be somewhat similar in construction to those described by Mr. Wenham in his exceedingly clever and able paper read at the first meeting of the Society, in 1866, which he then repudiated as utterly impracticable. The reason I propose at once trying what seems to be a proper length of wing is, that although I agree with Mr. Wenham that the slip of the screw renders it an undesirable sustaining power, I still think that superposed planes are in a measure liable to the same objection at low speeds as the screw, viz., that they, though probably in a much less degree, use the same air more than once.

These wings, which of course girder-like and bird-like would, if supported at the tips, be capable of sustaining the weight of the operator in the middle, would at their extremities be fitted with grooved wheels, which wheels by means of vanes on them would detach themselves from the apparatus immediately on the experimenter cutting a line which hitherto had restrained them. An inclined plane, composed of two stretched ropes and placed tangentially to an average circle described by the pendulum, would serve to give the concern the requisite initial velocity, the wings being supported on the grooved wheels before spoken of. When the man came to the end of this plane the pendulum line would come into action, and, in the event of his coming to grief, would catch him ; but if it proved successful he could soar round and round without the slightest fear of danger. This experiment, and of course it would be nothing but an experiment, could be carried out without the aid of the inclined plane, but I am inclined to think it would be more satisfactory with it. I cannot forbear conjecturing that if such an experiment as this did prove a failure (as it doubtless would the first time of trial) we should still have learnt far more from it in a day than we could by talking here for a month. I have neither the time, place, inclination, nor means to carry out such an undertaking as this entirely on my own account, but I should be glad to co-operate with the council of this society in trying some such experiment or any modification of it, and would cheerfully offer my services and lend myself as the pendulum bob or chief victim.

Another experiment, which seems to me well worthy of trial and investigation, is one with which you are all familiar, proposed by Mr. St. Martin and afterwards with modifications by Mr. Stewart Harrison, which I will call the "velocipede aerostatic apparatus." The speed of the velocipede is, however, but small when regarded as the initial speed of flight, and with a view of increasing this speed I venture to suggest an amendment.

Some years ago—before the velocipede mania had existence—I tried many experiments with what I may term a species of wheel skates, the wheels being of considerable diameter and having their centre somewhere about the region of the knee. The speed I managed without any fatigue to attain was something tremendous and almost incredible, but the bruises and falls I managed to sustain were equally tremendous and almost incredible, and bodily fear at length led me to discontinue the trials. It occurred to me last week that this apparatus, in conjunction with wings, might prove tolerably safe, while it would supply the speed asked for by so many. To such, or any interested in this kind of research into flight, I shall be happy to afford any further information they may require.

Let us do something, take some active steps, and not let another year roll by spent in dreamy speculation and unprofitable theorizing. The prayer of Ajax should be ours—light, more light. Experiment would clear away many imaginary obstacles. In nearly every great discovery difficulties have been thought to exist which practice has dissolved as the sun a morning mist. Locomotives were constructed with clog wheels to gear into racks till practice proved that smooth tyres and rails met all requirements, and then how easy all calculations on adhesive force and friction became. It will, I trust, be found to be so with flight ; the dust of power and weight is at the present moment thrown in our eyes, which I believe the water-cart of practice would

easily lay. Let us in our experiments bear in mind Solomon's description of the inventor, "I Wisdom dwell with Prudence and find out knowledge of witty inventions." May these twin attributes of the successful discoverer, Wisdom and Prudence, ever pervade our meetings here, and take up their abode with our individual researches at home.

I do not invite or even wish for discussion on this paper, it is simply unworthy of it, as I have merely tried to show you how little we know on the subject of flight, being well assured that the first and most important step towards knowledge is a thorough conviction of ignorance. In conclusion, you will allow me to assure you all that I shall be well satisfied if the display of my ignorance will lead and encourage you to exhibit your knowledge and help to provoke inquiry into and to develop, in however small a degree, the theory, and more particularly the practice, of so important but hitherto so unattainable a subject as the science of flight—not the science of artificial flight only, but the science of natural although manual flight.

ON THE MOTION OF WATER IN RIVERS AND CANALS.

By ALBERT HILL, C. E.

I. *Average Velocities.*

Water moves either in natural or artificial channels. In the first case it forms rivers, brooks, etc.; in the second, canals, ditches, etc.

The bottom and side-slopes of the channel constitute what is termed the *bed.* A plane which is vertical to the direction of the current gives by its intersection with the bed, the *cross-section*, the area of which we shall designate in these pages by a. That part of the cross-section which is in contact with the water is called the *water-perimeter*, and will be designated by p. Any vertical plane in the direction of the current gives the *profile* of the bed.

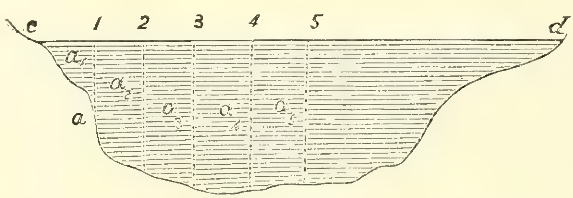
The cause of the motion of water in its bed is simply gravity, inasmuch as the bottom is an inclined plane. By *fall* we understand the perpendicular distance of any two points of the profile.

Between the fall h, the distance l, to which this fall corresponds, and the angle S which the bottom or the surface forms with a horizontal line, there exists the relation

$$\sin \delta = \frac{h}{l}$$

The velocity of the current is different in different points of the same cross-section; it is greatest in the point farthest from both bottom and side-slopes, and decreases with the distance from these.

By average or *mean-velocity* is meant



that uniform velocity which the current is supposed to have in every part of the cross-section in order to discharge the same quantity of water as is actually discharged with different velocities.

Let Q be the quantity of water discharged in one second through a certain cross-section, c the average velocity of the current, then we have the equation

$$Q = a\,c$$

In order to ascertain the average velocity of a cross-section, the following method is resorted to:

On the line $c\ d$ of the surface several points, 1, 2, 3, 4, are taken at a certain distance from one another.

From these points perpendicular lines are supposed to be drawn to the bottom, and then the areas a_1, a_2, a_3, a_4, a_5, of these parts of the cross-section, thus formed, calculated.

Three different velocities v_1, v_2, v_3 (at the top, middle, and bottom), in the same perpendicular are then ascertained, added together, and their sum divided by the number of observations, for the average velocity of that perpendicular, *e. g.*, the average velocity of the perpendicular 1 *a* would be

$$\frac{v_1+v_2+v_3}{3}$$

of 2 $$\frac{v_1'+v_2'+v_3'}{3} \text{ etc.}$$

Each of these average velocities is now multiplied by the corresponding part of the cross-section, thus

$$a\left(\frac{v_1+v_2+v_3}{3}\right),\ a_2\left(\frac{v_1'+v_2'+v_3'}{3}\right) \text{ etc.}$$

These products all added and their sum divided by the entire cross-section will give the average velocity of this latter.

Various instruments have been constructed by which to ascertain the velocity of currents. The simplest of these are the so-called "*swimmers*," hollow spheres of tin, partly filled with shot to secure their immersion, and varnished with some bright color to render their motion more easily observable. The velocity of the current is found by dividing the distance l by the time t which it takes the swimmer to pass over this distance; hence

$$v_1 = \frac{l}{t}.$$

To ascertain the velocity in different depths, two swimmers are connected by a wire, one of which is so ballasted as to sink completely, the other sufficiently to permit its being perceived just above the surface.

Let c represent the velocity of the upper swimmer alone, v the velocity of the two combined, then will x, the velocity of the lower swimmer be found from the equation

$$x = \frac{c+v}{2}$$

The *river-quadrant* which is employed to find the velocity of a current on the surface of the water consists of a graduated quadrant and a ball suspended in the centre by a thread. The specific gravity of the ball must be greater than that of water.

The velocity is calculated from the angle which the thread makes with the perpendicular arm; for from the weight Q of the ball under water, and the thrust $P = a\,v^2$ (since this latter increases uniformly with the square of the velocity and the area of the section of the ball), is obtained a resultant force, the direction of which is imparted to the thread, and the relation of its angle with the perpendicular is expressed by

$$\text{tang.}\,\alpha\,\frac{\mu\,a\,v^2}{Q} \text{ whence}$$

$$v = \sqrt{\frac{Q}{\mu\,a}}\cdot\sqrt{\text{tang}\ \alpha}$$

in which μ is a co-efficient found by experiments.

$$\text{Making } m = \sqrt{\frac{Q}{\mu\,a}} \text{ we have}$$

$$v = m\sqrt{\text{tang.}\ \alpha}$$

in which m is again a coefficient found by experiments. This coefficient is constant for the same ball, and is best found by immersing the ball in water, the velocity of which is already known. Dividing v then by tang. α gives the constant m for all other experiments with the same instrument.

The numerous experiments made by different engineers have not as yet resulted in the establishment of a general law for the different velocities in the different points of a cross-section. Egtelwein and others believe themselves to be correct in asserting that the velocity in the same vertical decreases from the surface with the depth in an arithmetical progression.

Let V be the velocity, m the depth of the river in metres, v the velocity in a certain point, then would

$$v = V\,(1-.025\,m).$$

a result which the experiments of others do not verify.

Let C represent the maximum of velocity in the channel, c the average velocity of a cross-section, then we have nearly correct:

$$c = 0.84\ C$$

for C within the limits .2 and 1.5 metres.

For other values of C Prony proposes the formula:

$$c = \frac{C\,(2.372+C}{3.153+C}$$

Baumgartner does not think this formula quite reliable for greater velocities on the surface, and advises the multiplication of the second member of that equation by 0.8.

II. *Uniform motion of water in canals.*

If the average velocity c remains the same for a greater distance l, and if therefore for this latter, the cross-section a remain the same, then the water moves uniformly. The fall h is employed only to overcome the resistance in the bed, and we have

$$h = \mu + \frac{l\eta}{a} + \frac{c_2}{2g}, \text{whence}$$

$$c = \sqrt{\frac{2g}{\mu} \times \frac{h}{l} \times \frac{a}{\mathrm{P}}}$$

in which μ is a coefficient found by experiments, and p the water perimeter.

According to Egtelwein and Buat $\mu = 0.0081$. Substituting this rule, and for $g = 9.809$ metres, we have for the metric system

$$c = 49.2\sqrt{\frac{h}{t} \times \frac{a}{\mathrm{P}}}$$

The coefficient of resistance μ is not quite constant, but decreases with a greater and increases with a less velocity.

Weisbach makes

$$\mu = 0.007409\left(1 + \frac{0.05853}{c}\right).$$

In the construction of canals the cross-section must be so chosen that the fraction $\frac{\mathrm{P}}{a}$ becomes a minimum; hence the perimeter must become for a given area a minimum, or the area for a given perimeter a maximum.

In canals the cross-section is usually a rectangle or a trapezoid, which being given, the water perimeter must become a minimum.

Making the basis of the rectangle y, and the altitude x, then will

$$(1)\ a = x\,y \text{ and}$$
$$(2)\ p = y + 24 \text{ or}$$
$$p = \frac{a}{x} + 2x.$$

Changing x into $x + \triangle x$, where $\triangle x$ denotes a very small number, and developing, we have

$$p' = \frac{a}{x} + 2x + \triangle x\left(2 - \frac{a}{x2}\right) + a\frac{\triangle^\circ x}{x3} + \ldots$$

If this value of p' is to increase now for any positive or negative value of $\triangle x$, we must have

$$2 - \frac{a}{x^2} = 0, \text{ whence}$$

$x = \frac{1}{2}\sqrt{2a}$, and substituting this in eq. (1) $y = \sqrt{2a}$, *i. e.*

The altitude of the rectangle must be equal to one half its base, or the cross-section is to be half of a square the side of which is equal to $\frac{1}{2}\sqrt{2a}$.

For a trapezoid in which the area a and the angle β of the side slope are given, we have

$$(3)\ a = \left(\frac{2y + 2x.\cos.\beta}{2}\right) x \sin\beta \text{ and}$$
$$(4)\ p = y + 2x$$

in which y is equal to the lower base, and x to the length of the side slope.

Expressing y in terms of x, equation (4) becomes

$$p = \frac{a}{x \sin.\beta} + x(2 - \cos.\beta) \text{ and}$$

$$\text{for } p' = x + \triangle x \text{ we have}$$

$$p' = \frac{a}{x\sin.\beta} + x(2 - \cos.\beta) + \angle x(2 - \cos.\beta - \frac{a}{x^2 \sin.\beta} + a\frac{\triangle^2 x}{x^3 \sin\beta} + \ldots..$$

And as condition for the minimum

$$2 - \cos.\beta = \frac{a}{x^2 \sin.\beta,} \text{ whence}$$

$$x = \sqrt{\frac{a}{\sin.\beta\,(2 - \cos.\beta)}}$$

and $$y = \frac{2\sqrt{a.}\,(1 - \cos.\beta)}{\sqrt{\sin.\beta\,(2 - \cos.\beta)}}.$$

Making the angle of the side slope 60°

$$x = y = \tfrac{2}{3}\sqrt{a.\sqrt{3}}.$$

III. *Unequal motion of water in rivers.*

When the average velocities in the different cross-sections are unequal the motion of the water will not be uniform.

In this case we suppose a certain distance of the river to be divided into smaller parts, for each of which the area a of the cross-section, the perimeter p, and the velocity v, may be considered constant.

Let v be the velocity at the beginning of such a part, v_2 the same at its end, l the length of the part, h the fall, corresponding to l, then will

$$h + \frac{v_1^2}{2g} = \frac{v_2^2}{2g} + \frac{\mu p l}{a} \times \frac{v^2}{2g,} \text{ whence}$$

$$(1)\ h = \frac{v_2^2 - v_1^2}{2g} + \frac{\mu p l v^2}{2ag}$$

Designating by a_1 the first, and by a_2 the second cross-section of the distance, l then is

$$a_1 v_1 = a_2 v_2 = a v; \text{ whence}$$
$$v_1 = \frac{a_2}{a_1} v_2$$

and substituting this value in eq. (1), we have

$$(2)\ h = \frac{v_2^2}{2g}\left[1 - \left(\frac{a_2}{a_1}\right)^2\right] + \frac{\mu p l v^2}{2 a g.}$$

The correctness of this formula which is used for the motion of water in rivers increases with the decrease of l.

Introducing in eq. (2) the quantity Q of the water discharged, instead of the velocities, we have since

$$Q = v_1 a_1 = v_2 a_2 = v a$$

$$h = \frac{Q^2}{2g}\left[\frac{1}{a_2^2} - \frac{1}{a_1^2} + \frac{\mu p l}{a 3}\right], \text{ whence}$$

$$Q = \frac{\sqrt{2 g h}}{\sqrt{\frac{1}{a_2^2} - \frac{1}{a_1^2} + \frac{\mu p l}{a^3}}}$$

Making in this last formula

$$a = \frac{a_2 + a_1}{2}$$

then eq. (3) becomes

$$Q = \frac{\sqrt{2 g h}}{\sqrt{\frac{1}{a_2^2} - \frac{1}{a_1^2} + \frac{8 \mu p l}{(a_2 + a_1)^3}}}$$

Designating the upper depth by m_1 the lower by m_2, the angle of the bottom by δ, then is

$$h = m_1 - m_2 + l \sin.\ \delta, \text{ and}$$

$$m_1 - m_2 + l \sin.\ \delta = \frac{Q^2}{2g}\left[\frac{1}{a_2^2} - \frac{1}{a_1^2} + \frac{8 \mu l p}{(a_2 + a_1)^3}\right]$$

This gives for that value of l which corresponds to $m_1 - m_2$.

$$l = \frac{m_1 - m_2 - \frac{Q^2}{2g}\left(\frac{1}{a_2^2} - \frac{1}{a_1^2}\right)}{\frac{8 \mu p}{(a_2 + a_1)^3} + \frac{Q^2}{2g} - \sin.\ \delta.}$$

If $a_1 = m_1 l$; and $a_2 = m_2 l$; *i. e.* the width of the river being constant, we have

$$l = \frac{m_1 - m_2 - \frac{Q_2}{a g} \cdot \frac{m_1^2 - m_2^2}{m_1^2 - m_2^2 - b_2}}{\frac{1}{(m_2 + m_1)^3} \cdot \frac{8 \mu p}{b^3} + \frac{Q^2}{2g} - \sin.\ \delta}$$

Substituting for Q its value

$$Q = m_1 b v_1$$

we have

$$l = m_1 - m_2 \cdot \left(\frac{1 - \frac{v_1^2}{2g} \cdot \frac{m_2 + m_1}{m_2^2}}{\frac{8 \mu p}{l\,(m_2 + m_1)^3} \cdot \frac{v_1^2}{2g} - \sin.\ \delta}\right)$$

For small values of l we can suppose

$$m_2 + m_1 = 2 m_1$$
$$= 2 m_2, \text{ whence}$$

$$l = m - m_2 \times \left(\frac{1 - \frac{v^2}{2g} \times \frac{2}{m_1}}{\frac{\mu p}{m_1 b} \cdot \frac{v_1^2}{2g} - \sin.\ \delta}\right).$$

FILTRATION OF TOWN SEWAGE.

From "The Builder."

The new Royal Commission, appointed in 1868 to inquire into the best means of preventing the pollution of rivers, took up the subject where the former Commission had left it,—that is, after the Thames, the Lea, and the Aire and Calder basins had been reported upon, and have now issued their report on the Mersey and Ribble basins. They come to the same conclusions as the former Commission did in respect of the irrigation of land with town sewage being the best means of preventing the pollution of rivers with it, as well as being the most profitable in application; but they state the case in a different way to that in which the former Commission put it. They say that sewage may be sufficiently purified to be allowed to flow into any river or other watercourse, from which it is not intended to take water for domestic use, by *filtration* through sand or porous soil, as distinguished from the view that some persons take of irrigation, which is, that the sewage is purified by running over the surface of the land in a thin sheet, parting with some of its manurial elements to the plants, and storing the remainder in the top soil for the use of the next crop, or rather for the use of the crop first sown after re-ploughing the land ; whereas the present Commissioners say that it is the filtration through a sufficient thickness of sand or porous soil that constitutes the efficiency of this method of utilizing sewage ; and that therefore, its purification is insured by passing it through constructed filter-beds equally well as by passing it through the natural soil of the land. This they have ascertained by experiments with several kinds of soil, with sand, and with sand mixed with coarsely powdered chalk.

The difference between filtration through constructed filter-beds and through the soil of the land is one not of efficiency of purification, but of the profitable application of the sewage, the former method being unremunerative, while the latter is remunerative. But it is consolatory to know that in places where land cannot be had for irrigation, the sewage may yet be sufficiently purified to be allowed to flow into rivers, although the value of the solid part of the sewage which is retained may not be of much value. The value of it will evidently depend on the quickness with which it can be extracted in respect of the length of the time elapsing from its entry into the sewers to its extraction at the outfall. Where the gradients are considerable, and the mean distance of the outfall from the town is not very great, it may be arrested in a fresh state ; and, mixed with street sweepings and other town refuse, may become of considerable value ; while, where the gradients are slight, and the outfall at a greater mean distance from the town, it may become so far decomposed in its transit as to be of no value as a manure.

The Commissioners estimate that for a town where water-closets are in general use (therefore requiring a larger area than would be required where they are not so numerous), 5 acres of filtering surface, and a depth of material of 6 ft., are sufficient for a population of 10,000. According to their experiments something of this depends on the nature of the soil or other material used for the filter-bed, the qualities of various soils for this purpose differing ; for while soil procured from Dursley, in Gloucestershire, purified sewage at the rate of 9.9 gallons per cubic yard per day, soil from Hambrook, near Bristol, did not satisfactorily purify more than 4.4 gallons per day per cubic yard. Again, soil from Beddington purified sewage of the same strength at the rate of 7.6 gallons per day, while that from Barking did not purify it at a greater rate than 3.8 gallons, or peat from Leyland Moss, near Preston, at a greater rate than 4 gallons per day per cubic yard of material.

Considering that "filtration" has already often been employed to purify sewage, and has always hitherto failed, it is rather startling to see it so confidently recommended, until we remember that both the methods of filtration that have failed for sewage also failed for water many years ago ; that is to say, the horizontal method and the upward method, while, as soon as the late Mr. James Simpson re-arranged the filter-beds of the Chelsea Waterworks at Thames Bank many years ago, and made the water to descend instead of ascend through the filtering medium, the question was then and thereafter settled as to whether water should be filtered upwards or downwards. Every engineer since that time—every engineer, that is to say, who has had the knowledge to perceive the difference between a true and scientific and a false and empirical method, or who has had the honesty to acknowledge that he was not the inventor of the practice he has adopted,—all these men have adopted the downward system of filtration of water. And so we find the Commissioners—or, shall we rather say, Dr. Frankland, one of them ?—condemning the system of upward filtration now in practice at Ealing, and giving the reason why downward filtration is so effective in purifying sewage. The system at Ealing is to force the sewage upwards through a filtering medium constantly, thereby effecting no proper purification at all ; but by making the sewage to descend for six or twelve hours through one bed, then shutting it off from that bed, or compartment, and turning it on to another for a like space of time, and so alternately, the descent of the sewage through the interstices of the material on either bed is followed by atmospheric air ; the air, that is to say, that occupied these interstices before the sewage began to descend and has been used up in oxidizing and transforming, and therefore purifying, the former quantum of sewage, is replenished after the descent of each quantum of sewage through each bed, and so by continual periodical renewals of the proper aëration of the filtering medium, it becomes a constant purifier of the sewage ; for, although this method of filtration in the case of water has mostly been called a mechanical one only, yet, in the case of sewage filtration, the same method is said by the Commissioners to be both mechanical and chemical.

In order that there should be no ambiguity about what they recommend, and its attainment, they give a standard of impurity beyond which they think the water of sewage ought not to be admitted into

rivers or other watercourses. They suggest that the following liquids be deemed polluting and inadmissible into any stream :—

"Any liquid containing, *in suspension*, more than 3 parts by weight of dry mineral matter, or 1 part by weight of dry organic matter in 100,000 parts by weight of the liquid.

"Any liquid containing, *in solution*, more than 2 parts by weight of organic carbon, or .3 part by weight of organic nitrogen, in 100,000 parts by weight.

"Any liquid which shall exhibit by daylight a distinct color when a stratum of it, 1 in. deep, is placed in a white porcelain or earthenware vessel."

So far the standard is applicable to any town. But the Commissioners, having before them the question primarily of the pollution of the rivers Mersey and Ribble, which traverse the manufacturing part of the county of Lancaster, found it necessary for that district to prohibit—suggest, rather, that they should be prohibited—many kinds of pollution peculiar to the manufactures of those parts, *e.g.* :—

"Any liquid which contains, *in solution*, in 100,000 parts by weight, more than 2 parts by weight of any metal except calcium, magnesium, potassium, and sodium.

"Any liquid which contains, whether *in solution or suspension*, in chemical combination or otherwise, more than .05 part by weight of arsenic.

"Any liquid which, after acidification with sulphuric acid, contains, in 100,000 parts by weight, more than 1 part by weight of free chlorine.

"Any liquid which contains, in 100,000 parts by weight, more than 1 part by weight of sulphur, in the condition either of sulphuretted hydrogen or of a soluble sulphuret.

"Any liquid possessing an acidity greater than that which is produced by adding 2 parts by weight of real muriatic acid to 1,000 parts by weight of distilled water.

"Any liquid possessing an alkalinity greater than that produced by adding one part by weight of dry caustic soda to 1,000 parts by weight of distilled water."

The opinion of the former Commission was that sewage could not be filtered. "As applied to sewage, disinfectants do not disinfect, and filter-beds do not filter," they said. Sewage applied constantly to a filter-bed on the upward system does not purify sewage continually, certainly; and if that was the system meant to be understood, the former Commission were clearly right in their statement, but on the downward system the case is different. Any one who remembers the condition of the Thames when the Lambeth Company took their water from a point of the river near Hungerford Bridge, and when the Chelsea Company took their supply from Thames Bank, may well compare the water then taken from the river for the supply of a large part of London with the town sewage of to-day. The reports of the engineers were constantly that the water was "turbid;" but that word, as now used sometimes to define the condition of the Thames water, conveys no idea of the state of the water at that time. In comparison with the turbidity now sometimes said to exist, it might be called pea-soupy, or sludgy, and yet this very foul water was passed through filter-beds on the banks of the river, after subsidence in reservoirs, and transformed into the brightest and most pellucid water, as drawn from the filtered water well. No doubt the surface of the filter-beds often required cleaning; the mud deposited soon stopped up the pores of the sand so that no more water would pass, and this necessity of frequent shutting off and turning on of the water may have been the cause, as illustrated by the view the present Commission take of the subject, why these filter-beds were so perfect in action under such difficult circumstances; the air filling the interstices of the filtering medium—sand and gravel—after the mud was scraped from the surface of the sand, was replenished at short intervals, and so kept the filter-bed continually perfect.

Manchester being within the water-shed of the river basin inquired into by the Commission, it became necessary for them to institute an inquiry into the merits of the privy and ash-pit system, as against the water-closet system, especially as that city is the great stronghold of this first-named system.

Agreeing with every other impartial inquiry into this subject, the present Commission condemn it. They illustrate the case in a remarkable way. They suppose all dwelling-houses, warehouses, etc., to be removed, and only the privies left—nearly 60,000 of them in Manchester and Salford—rows and streets, and crowds of them—

scattered about almost as thickly in places as the heaps of manure upon a field that has just received a dressing from the dung cart—each heap here, however, no mere barrow-load once a year, but a constant collection and continual soakage of filth, which has for years been polluting every corner to which air or water could have access. *Is this the site on which to build a healthy town?* Would it not be the first desire of every sensible man to sweep this filth away, to drain and aërate, and, if possible, to sweeten this land before a single dwelling-house should be built?

On the great question of establishing a River Conservancy Board, the present Commissioners agree with the recommendations of the former Commission, to the effect that it is highly desirable that such a Board should be established for every river basin; but on the secondary question of how and of whom it should be constituted, the chairman, Sir W. Denison, does not agree with his colleagues, Dr. Frankland and Mr. John Chalmers Morton, and on that subject they give separate reports. The chairman advises a parochial system; that the officers of such parishes as the stream flows through should be the persons responsible for the state of the river flowing through their respective districts, but, anticipating abuse of the powers placed in their hands, he recommends that they be made sufficiently responsible to the general government to enable the latter to check or prevent any such abuse, or to notice and reprove, and even to punish all negligence or unfairness in the mode of action of the former. The initiation of action is to be the complaint of neighbor against the conduct of neighbor.

Let us take a supposititious case, and inquire how this would be likely to work in practice. Suppose two of the uppermost mills or towns on a stream to use the water that comes to them with satisfaction to themselves, but that one or both of them foul it so as to be unsatisfactory to the third person or town, the one below them. Of whom is the third party to complain? And, of course, the difficulty is increased if three or more parties are satisfied, and the fourth or fifth complains.

The boundary of the district over which each parochial Board is to have jurisdiction being conterminous with that of the parish, how are the officers of the parish injured to determine who above them has caused the injury? If all are complained against, who shall determine the degree in which each has contributed to the pollution of the river?

Dr. Frankland and Mr. Morton recommend that, inasmuch as there exist at present no local bodies competent to deal with questions connected with efficient river conservancy, capable of detecting pollutions and enforcing remedies, it will be necessary to call into action an authority possessing greater capacities and powers than those of the existing corporate bodies or local boards. The duties of this authority would be of two distinct kinds: the one would be those of a river police, employed in the detection of offences, and in obtaining the conviction of offenders; the other would include the investigation of and decision upon various works connected with rivers, proposed by either towns or individuals, such as schemes for water supply and for the defecation, filtration, or utilization of sewage and other polluting matters, while local boards could obtain information on these points only capable of investigating them. Nevertheless, under the second division of the duties of the central authority, the co-operation of the local corporations would be required for the efficient discharge of them. Indeed, if guided and assisted by a properly qualified central court, the present local boards would be quite competent to meet all local difficulties and to supply all local wants. A central authority would not extinguish the corporations and local boards at present existing in the river basins. It would, the Commissioners believe, materially promote the energy of local action by removing the obstacles which at present hamper it, and by giving a prompt decision to the questions which it has to solve.

A RETURN has just been published showing the quantity of guano used in Austria, in each year from 1861 to 1869. In 1861 it was 12,819 cwt.; in 1862, 13,370 cwt.; in 1863, 18,650 cwt.; in 1864, 35,264 cwt.; in 1865, 45,264 cwt.; in 1866 (the year of the war with Prussia), 23,846 cwt.; in 1867, 63,446 cwt.; in 1868, 67,684 cwt.; in 1869, 106,514 cwt. The above figures include the guano used in Hungary.

THE JAPANESE RAILWAYS.

From "The Railway News."

We bow our head "one hundred times with profound respect" to Tanishokei Menamoto no Marasada. A century hence, when Yokohama produces its Samuel Smiles to record the history of the men who have done good service to their country, he will assuredly give a very high position to the gentleman whose name we have given above, and who is the author of an essay on the "Introduction of Railways and Telegraphs into Japan," and of petitions in favor of the same. Marasada is no ordinary man. He has taken up the question of railways and telegraphs after mature and careful deliberation. He is evidently a close observer and an able reasoner. He has already, as he states in his petition, "represented his humble views respecting the removal from circulation of the debased currency;" and it is possible that upon this matter he may have arrived at conclusions somewhat more sound than those put forward by our own Chancellor of the Exchequer for sweating the British sovereign. Marasada has, he tells us, also "occupied his private leisure in studying the constitutions of foreign countries, and here, too, he is profoundly ashamed." He has formed opinions which he is prepared to stand by at all risks. "Your servant," he says, "is willing to undergo beheading or boiling alive for his opinions. Those who do not know how stupidly honest he is, say that he is carried away by a love of what is new and strange." Men of progress nearer our own country have been subjected to precisely the same imputation. Hear, however, how the man of progress in Japan puts his enemies to the rout :—

"It is his humble opinion that the old exclusive spirit is still alive, and that the vicious habit of taking superficial views is not yet eradicated. Narrow views, such as might be held by a frog that lives in a well, are daily becoming more and more rife, and they not only find a vent in every-day conversation, but are boldly proclaimed in high official quarters. These persons are an obstacle to the progress of civilization, and injure the wealth and power of our country. They do not know that in order to defend ourselves against the foreign barbarians, whom they so much detest, the wealth and power of Japan must be the chief means. Such persons are really anxious to return to the old state of things, when men lived in hollow trees and caves like beasts."

While anxious, however, to see great reforms carried out in his country, Marasada is at heart a good and sound conservative. Were he in this country he would be classed among the Liberal-Conservatives of our political party. "It is the prayer of your servant," he writes, "that the great principles of the Constitution may be maintained, that attention be not drawn off to petty advantages or shallow sentimentalities, but that, regardless of the remonstrances of such men, a decisive order for the introduction of railways be given. Then the people of Japan will have placed before their eyes the advantage of this invention, and the proverb that 'to see once is better than to hear a hundred times' will be exemplified. When the railway has been constructed machinery of all kinds can be introduced, commencing with appliances for the cultivation of the mulberry tree, the silk culture, weaving, and for cleaning rice. Thus will a great stimulus be given to production, and foreign gold and silver made to flow towards Japan. If, under present circumstances, the railway project should fall to the ground, from a dislike to the trouble of carrying it into execution, your servant fears that the results to the empire will be calamitous." Well argued, Marasada! and your opinions have all the more weight, seeing that they are those expressed by one of the old Court nobles of Kioto, from whom, as from the old-fashioned Tories of our own country, such sentiments were by no means to be expected.

The opinions of Marasada are also shared by some other members of the Japanese Government, and a paper just presented to Parliament on affairs in Japan gives us "An Essay on the Introduction of Railways and Telegraphs into Japan," and a "Proposition for the Creation of a source of Wealth for the Promotion of the Imperial Felicity, and the Establishment of an Unlimited and Ever-

lasting Benefit to the Nation." The author of this essay complains that "the energy of the people is on the decline, the national debt is on the increase, and the voice of the poor in their misery fills the streets; the people of the towns through which the high road runs are poor and suffering in their unmitigated misery. Their old parents are neglected, and mothers cannot marry their daughters." As a remedy for this state of things, railways and telegraphs are suggested, and those who object to the introduction of such new-fangled things, on the ground that they would only "astonish our people's eyes and frighten their ears," are compared to persons of narrow views and small minds who "look at heaven through a hole in a small bamboo."

"I maintain," writes the author, "that the future of a country lies in its people, and the way to enrich the people is to encourage the productions of industrial labor. In these efforts the economy of human labor is of paramount importance. This is only possible by the introduction of telegraphs and railways. If a proof for this assertion is wanted we need only look to the condition of those nations which we now call great and highly civilized, say England or France, and a hundred years ago, when they had not been able to overcome the disadvantages of an exclusive employment of human forces for labor of all kind. Since the introduction of railways and telegraphs into those countries a hundred other useful and profitable discoveries have been added, the distances of thousands of miles are now traversed by horses and wagons or boats in a moment. Government dispatches its orders in all directions with celerity and promptness. Thus have the present wealth and power of those countries been created."

In conclusion, writes this Oriental philosophical statesman:–

"Let us hope that these objects may be obtained, and that they may become the source of our national prosperity, and promote the Imperial felicity. We may then say in truth that the basis of our independence and liberty as a free nation was the introduction of telegraphs and railways."

A second minute on the advantages to be gained from the construction of railways points out that, if made, places now at a distance would

"Become neighbors, and, as it were, one continuous street. Aged men, women, and children would travel with ease, and trade would become more and more flourishing. In future, chair-bearers, horse-boys, boatmen, and innkeepers will reap the benefit of the increasing prosperity, and they will be able to find some means of gaining a livelihood. For the present the execution of this great undertaking will afford employment to large numbers of the lower class in Yeddo and the vicinity, and give them the means of supporting themselves. This will naturally accustom them to the idea of a railroad, and thus the way will be prepared for its future extension, as above proposed, to the other provinces."

A despatch from Sir H. Parkes to the Earl of Clarendon announces the success which has attended these endeavors to enlighten the Government on these subjects, by the authorization of the Japanese railways, the capital for which has already been provided in this country. In this despatch Sir H. Parkes says it is essential to the establishment of a vigorous and compact administration under the new constitutional system, and of equal importance to the interests of commerce and the industry of the people, that improved means of communication should be provided. Japan, unlike China, does not possess navigable rivers; the rate of travelling averages only 20 miles a day, and provinces that are separated by 400 or 500 miles are at nearly a month's distance from each other. The two capitals of Yeddo and Kioto, though connected by the best line of road in the country, are a fortnight's distance apart, and the difficulty of transporting rice often exposes one part of the country to scarcity and distress while another district may be wanting an outlet for its produce. At the close of last year Sir Harry was informed by the Government that they had resolved to construct a railway between Yeddo and Kioto. Their difficulty in making a commencement lay in the want of funds, and this was met by an offer on the part of Mr. H. N. Lay, formerly of China, and who was then visiting Japan, to lend the Government £1,000,000 sterling, on the security of the projected line of railway and the Customs revenues. This offer he

accepted, and Mr. Lay returned to England to raise the above sum, and to engage the necessary engineers for the work. These are to be employed by the Japanese Government, under the direction of Mr. Lay, who has the right of superintending the construction of the railway, though all the plans and details have to be approved by the Japanese Government. The measure was strenuously contested by the party opposed to progress, and also by those who were unable to appreciate the advantages of the innovation; but the Government gave evidence that the question was fairly understood by its advocates, and Sir Harry now feels assured that the execution of the scheme may be proceeded with, and that, as the chief engineer, Mr. Morel, has reached Japan, they intend that he shall at once commence to survey the line between Yeddo and Yokohama. In the same despatch it is mentioned that an experimental line of telegraph, constructed by Mr. Brunton, is already working between Yeddo and Yokohama. Many Japanese foretold failure. It was believed the wires would be constantly cut, and in the popular mind the enterprise was connected with necromancy and Christian propagandism. The only injury done, however, has been some hacking of the posts by two-sworded roughs; and the single wire is now found scarcely sufficient to meet the demand for the transmission of Japanese messages between Yeddo and Yokohama. Mr. Brunton is consequently engaged in putting up a similar line between Hiogo and Osaka.

VARIABLE EXPANSION GEAR FOR WINDING ENGINES.

From "The Mining Journal."

An important invention, connected with the working of mines, is described in the French coal-trade paper, "La Houille." It is generally admitted that the application of expansion gear to engines insures an important economy of fuel, yet hitherto winding engines have been worked without it. The many conditions to be satisfied render it, indeed, difficult to apply, and cause mine owners who use unsalable debris for the raising of steam to hesitate before adopting it. But special circumstances have now made its application unusually desirable—the want of boiler space consequent upon the daily increasing activity at the pits. Thus, obliged as they would be to buy new boilers, it has been deemed preferable to utilize to a greater degree the steam already at their disposal, by causing it to produce more useful work by using it expansively. This secures not only the advantage of diminished consumption of fuel, but also renders available part of the boilers, the number of which had become insufficient. The question has been most successfully solved by Mr. Audemar, the engineer of the Blanzy mines. After having successively tested and rejected fixed cut-offs, as well as several special arrangements proposed to him, Mr. Audemar hit upon a form which was first tried for six consecutive months upon an engine of 250-horse power, and then, having succeeded perfectly, to six other engines of similar power, which were previously worked without a cut-off, and which now work with the greatest regularity on the works of the Blanzy Company.

The conditions which experience had proved to be necessary were—to work the machine with the expansion gear, and to be enabled to suppress the action of the cut-off instantaneously, when desired; to render unnecessary the attention of the engineer, who has already enough to attend to; not to increase the number of levers he will have to work, nor the power necessary to work them; and to make the cut-off variable, so as to adapt itself to the variations of resistance of the load to be raised. The apparatus consists of a double cam, one-half of which serves for the forward stroke, and the other half for the back stroke. Each portion of this cam has varied profiles, so as to give the various degrees of expansion, from the smallest to the greatest; and it is so disposed that the middle becomes the neutral point, like that of the Stephenson slide, and corresponds, like it, to no admission whilst the too extreme points give full open.

A valve on the Cornish system, placed before the ordinary distribution of the machine, is used to produce the expansion of the steam. This valve is put in motion by the cam, the rotation of which is caused by the gearing on the shaft of the engine, and it opens and closes according as one or other part of the cam is for the time being in operation. If the Stephenson slide be at its neutral point, the cam would be in a similar position, and the two being set in motion by the same lever, will at the same time occupy the extremes of their course. If, then, the engineer inclines his reversing lever, the several profiles of the cam being presented to the valve, produce a corresponding cut-off, which will become absolutely none if the lever be pushed full home. Thus, the mere inclination of the lever which the engineer already uses, suffices to produce the desired effect both for the forward and backward movement.

An essential feature is that the objections to the Stephenson slide when not at the extremities of its course are avoided. The connection of the slide with the cam is, in fact, made by intermediate sectors, so that the speed of the two parts is widely different. Thus the slide always occupies the end of its course, and gives the maximum opening to the ports, although the cam is sufficiently advanced to produce considerable expansion. The system, which appears to be free from complications, and which has been practically applied, has enabled the Blanzy Company to dispense with the purchase of boilers, which had become indispensable, and to secure in addition a saving of fuel equal in some cases to 40 per cent. And they were enabled in one case of four boilers already over-worked to put one out, for the purpose of cleaning. These results are so remarkable that the general adoption of the invention is confidently anticipated; and, as all the parts are ready made, the stoppage for a single day is sufficient to apply the arrangements to existing engines; and they, moreover, meet the approval of the workmen, because they do not at all interfere with their existing habits.

There are in the United States 48 manufacturers of railway cars. Seventeen of these are in Pennsylvania.

It is proposed at present to construct just 134 miles of street railways in the metropolis, but Mr. Haywood remarks that if the experiment be successful, not only London, but all our large towns, and not only our towns, but many of our country roads, will be traversed by these lines; that steam power will soon be substituted, in all probability, for horse power; and that, "unpleasant as the notion may now seem to us," we shall soon have engines dragging omnibuses along our streets.

Sleigh bells are attached to the points of the carriages on the Liverpool tramways to warn vehicles to get out of the way, which they are said to do very easily, even in the narrowest streets. The whole of the rails in the streets of Liverpool were laid in the night time, under the superintendence of an officer of the corporation, and the traffic was not interrupted for a single hour. Could not this be done in London?

A Moscow journal states that the railway bridge lately erected over the Dnieper, near Kiew, is one of the greatest works of the kind in the world, and the longest in Europe. It consists of 12 arches, and is 3,503 ft. in length. Capt. von Struve, who built it, has been promoted to the rank of colonel by the Emperor Alexander, on the recommendation of the Minister of Public Works.

It is estimated that, in round numbers, 110,000 tons of steel rails, equal to 1,100 miles of steel road, were laid in the United States up to the close of 1869. These rails are in use on more than 50 roads, chiefly of English, partly of American, and some of Prussian manufacture.

Pure silver, if highly heated in oxygen, will absorb 6.15 to 7.47 volumes of that gas, and under the same circumstances will take up 0.907 to 0.938 volumes of hydrogen, 0.486 to 0.545 carbonic acid, and 0.15 carbonic oxide; in this property it differs considerably from palladium.

THE CONVEYANCE OF SEWAGE.

From "The Engineer."

The best means, and those most efficient in a sanitary point of view, by which to accomplish the removal of the sewage of large cities and towns, have not yet been decided upon in that definite and conclusive manner which ought to characterize all the arrangements connected with matters of national importance. So far as the metropolis is concerned the question is virtually settled; but the different systems that prevail in Liverpool, Manchester, Dublin, and other cities possessing large populations, indicate unmistakably that great diversity of opinion exists on the subject. There is little doubt that, in many instances, the adherence to any one particular plan of operations is due solely to the circumstance that a town or district has committed itself to that plan, and prefers continuing to use it rather than submit to a troublesome and inconvenient change. This is by no means an uncommon thing in numerous other matters with respect to municipal and local jurisdiction. Without entering into the details of the various methods proposed, patented, experimented upon, and rejected, it will be sufficient to class them as all included under one of two general principles. The first is that which effects the removal of sewage by water carriage, that is, by sewers and drains; and the second comprises all other means and agencies not comprehended in the former. Briefly, these two systems may be appropriately termed the water carriage and the non-water carriage systems. The fact that London stands committed to the water carriage principle does not necessarily imply that that is the better of the two, or that others possess no merits or advantages of their own. It is only after an impartial and deliberate investigation of the separate systems that a fair estimate can be made of their respective value. A large amount of interesting and, what is more to the point, reliable information on this subject has been obtained by the Rivers Pollution Commissioners, and placed before the public in their recent report. The candid and disinterested manner in which these gentlemen conducted their inquiry sufficiently proves that they had no other object in view save the elucidation of the truth, and effecting a thorough and stringent investigation into every fact that had a proper and significant bearing upon the matter at issue.

It follows as a necessary consequence that wherever the water carriage system is in operation, the houses are supplied with closets, whereas in those instances in which another method of removing sewage prevails they are fitted with privies. What our own ideas, and those of the inhabitants of the metropolis, are with respect to the latter, would be truthfully represented if we could imagine our feelings on the supposition that every water-closet in London was removed and replaced by a privy. Nevertheless, in many towns and rural districts the introduction of water-closets is opposed with the greatest vehemence and hostility. So strong was this feeling at one time in Manchester, that when the corporation made an application to Parliament for the construction of water works, they asked for powers in their bill to enable them to levy one guinea per annum for every house subsequently provided with a water-closet. Whatever effect this might have had upon the superior classes of habitations, it would undoubtedly have totally prevented the introduction of the closet into those of an inferior description, where they are most needed. The argument most urgently and confidently put forward by the partisans of the non-water carriage system against the other is, that the latter directly pollutes and contaminates the natural watercourses of the country. It must be admitted that there is a great deal of truth in this assertion; but at the same time it is no valid argument against the water carriage principle, because, although the pollution of rivers and streams is unfortunately but too frequent a concomitant and a result of that system, it is not necessarily so. Were this pollution an inevitable consequence of the conveyance and removal of sewage by water, then that method would stand condemned, not only in a sanitary, but in every other point of view. But in reality this objection—which is specious even when examined theoretically—will, before long,

practically cease to exist. It has ceased to exist in many localities where its influence was widely extended and pernicious to the last degree. Owing to the stringent measures adopted, however tardily and reluctantly, by the sanitary authorities, some of our towns have adopted sewage irrigation, and no longer convert the nearest watercourse, as heretofore, into a wholesale receptacle for refuse of the most abominable description. If the report of the commission, to which we have alluded, receive that attention and consideration to which it is entitled in the cause of the public welfare, it will shortly be a penal offence to discharge sewage or refuse of any kind into any river or stream whatever.

When we investigate a little further the *pros* and *cons* of this question, it will be found that the opponents of the water carriage plan claim a complete immunity for their system from the evil which they allege accompanies the other. A few facts collected by the commissioners in evidence, which we shall presently advert to, proves this counter assertion to be utterly untrue. Omitting the pollution caused by manufactories and industrial establishments, as for the moment foreign to the comparison, the streams in the neighborhood of towns where privies were used instead of water-closets, were shown by analysis to be nearly as much contaminated as those which flowed through towns where the latter were employed. Theoretically the privy system will stand a favorable examination, but practically it proves wofully defective. If the cesspools were always water-tight, if they were at a proper distance from human habitations, if their contents were always sufficiently dried by the ashes thrown upon them, and if they were properly attended to and emptied when they required it, then possibly the soil, the air, and the stream might escape pollution. But how does the actual working of the principle bear out these very partial and one-sided suppositions? As facts, proved incontestably before the commissioners, the cesspools are not water-tight, are not at a sufficient distance from human dwellings, their contents are not dried by the ashes added to them, and they are not properly attended to and cleaned out at regular periods. Consequently the soil, the air, and the natural watercourses *are* polluted, the immunity from this evil assumed by the advocates of this method is devoid of foundation, and were we to inquire no deeper into the matter, there would be nothing to mark any relative superiority on either side. It would be to little purpose to mention a number of independent instances where the privy system is in full operation, and where, in order to abate the nuisance, it has been necessary to connect them with the town drains in order to get rid of their liquid contents. Let us select an example on a large scale, and one in which a very able and energetic local administration and strict police regulations prevail. Let us take the town of Manchester, where the management is very superior to that which prevails in places of inferior size and importance. In that town, among the poorer districts, the privies and ash-pits are in a chronic state of overflow and filthiness. Even in better parts of the town there are long rows of houses standing back to back, separated by an interval of only about 30 ft. This narrow passage is divided by a still narrower lane, on each side of which are the privies, one to each house, or sometimes in pairs; each pair having a common ash-pit. The emptying of these "middens," which includes twenty or thirty at a time, is accomplished at night, the contents being wheeled along the whole length of the narrow middle passage. Is it to be imagined that this can be done without poisoning and contaminating the air in the vicinity; or does the corporation suppose that because it is effected when people are asleep, and they do not perceive the abominable smell, that it is, therefore, innoxious and inoffensive? We may now allude to a circumstance in connection with this system which exhibits it in all its deformity, and displays its most revolting aspect. The scavengers divide the contents of the ash-pit into *wet* and *dry*. The former is conveyed, or rather imagined to be conveyed, to the manure depot; the latter is carted away to any convenient plot of ground which requires to be filled up—in a word, "where rubbish may be shot." To make this distinction between the wet and dry contents—or, under the circumstances, to attempt to make this distinction—is a practical absurdity, although there is little doubt that many would vigorously assert that it is made. These plots of land where rubbish may be shot, gradually be-

come filled up with this objectionable stuff; houses are built upon them, and is it a wonder that "typhoid fever, scarlatina, diarrhœa, and other zymotic diseases commit fearful ravages amongst the populations exposed to such pestiferous influences?" If this sort of foundation has been in vogue from early times, Manchester may be correctly described as a "collection of houses erected upon human dunghills." Not as an apology, but as a vindication of this forcible language, we quote the following brief paragraph from the report: "There is now a 'tip' in a ravine at Colyhurst, on the north side of Manchester, where the land is thus being raised *fifteen* to *twenty* feet over many acres, by the gradual accumulation of filthy rubbish." It may also be mentioned that the proof of what the rubbish consisted was readily arrived at by analyzing a sample of the water contained in a pool at the bottom of this tip, which fairly represented rain that had trickled through the disgusting mass. The average of two samples of this water contained in a hundred thousand parts 1976.95 parts of total solid matters in suspension, and was considerably richer in putrescible ingredients than any water-closet sewage which ever came under the observation of the commissioners. This explains the reason why it is so difficult to sell the so-called manure which composes the other parts of the contents of the ash-pits. It is, in fact, worthless.

Regarding the sewage question as consisting of two important features—the one the removal of the sewage from the vicinity of human dwellings, and the other its subsequent utilization—it must be admitted that the water carriage system effects the first in a manner that is impossible of achievement by any other means. There is no necessity of alluding to the superior cleanliness, and to the almost invisible agency by which this is accomplished, which are in perfect consonance with English tastes and habits. On the other hand, the rival principle does not remove the sewage from the neighborhood of human habitations; and, where it does accomplish this partially, it is by means that are highly offensive and injurious. With regard to the second part of the question, the non-water carriage method saves about four-fifths of the fecal matter of the population, mixes it up with a large quantity of ashes, and conveys it to the land at a much greater cost than it is worth. The water carriage plan carries the whole of the fecal matter away in a fresh condition, while that transported by the other plan is putrid. The *argumentum ad hominem* is usually regarded as an element of weakness in the party employing it. It is, however, sometimes singularly conclusive, and, applying it to our present comparison, it might be fairly stated that no one who had tried the water carriage system would for a moment entertain the idea of returning to privies and cesspools. But the same opinion does not prevail on the other side. On the contrary, the majority of those who have been condemned to endure the inconveniences and disadvantages attending the absence of water-closets would willingly adopt them, and place themselves under the same *régime* which makes London the best drained city in the world.

SPECTRUM analysis has been applied by Vogelsang and Geissler to the difficult question of determining the chemical nature of the fluid found inclosed, in minute quantity, in the cavities of certain quartz-crystals. Fragments of quartz, says the "Chemical News," were placed in a small retort, which was connected with an air-pump and exhausted; then, by the application of heat, the quartz decrepitated, and the evolved vapor was examined in a Geissler tube. The presence of carbonic acid was thus abundantly proved, and this was confirmed by the turbidity which it produced in lime water.

THE French steamship company, Les Messageries Impériales, having to ship a quantity of ice to Suez, for the use of its steamers in the Indian Ocean, and desiring to find the best quality for their purpose, subjected 100 kilogrammes (220 lbs.) of several kinds to the same conditions of temperature, with the following results:—(1) Natural ice from Switzerland lasted 107 hours; (2) natural ice from Norway, 115 hours; (3) artificial ice made by the Carré machine, 130 hours; (4) natural ice from Boston, Mass., 138 hours; (5) artifical ice made by the Tellier machine, 144 hours. Artificial ice, then, appears to be as solid as natural ice.

MANUFACTURE OF IRON—ON PUDDLING.

By MR. RICHARD LESTER.*

From "The Mining Journal."

From the earliest period of history iron-workers have existed. Tubal Cain is represented as the first instructor of the artificer in iron, but it has been worked upwards of 5,000 years, and from time to time has had the greatest amount of skill bestowed upon it; but with all this the constituent elements of iron are still unknown. Yet sufficient knowledge is attained to make iron in such quantities that, for really useful purposes, it may be fairly ranked as the king of metals. To enlarge upon its adaptation would be to deal with every domestic article, tools, implements, weapons of defence and offence, the iron rod, the stately ship, the domestic sewing-machine, or the fisherman's hook. I will not further expatiate on the purposes to which iron is applied, but will at once proceed with the methods for its manufacture. The earliest mode of making iron handed down to us was by long and constant refining in a bath of melted oxide, until it would stand the compression of the hammer. Iron in the malleable form was the production of the early artificers, but we have no account of crude cast metal from the ancients. Of late years iron manufacture has made giant strides; the making of small quantities of malleable iron in the shallow hearth is superseded by colossal smelting furnaces, where the ores are reduced to the metallic state, combined with many impurities. The cast has to be wrought or puddled before it is what is termed malleable iron.

In the years 1783 and 1784 Mr. Cort, of Gosport, invented certain methods of puddling, a process by which iron was really made in larger quantities, and his invention proved of great value, both in his time and to the present generation, so much so that he is styled the father of iron works. Mr. Cort's process was to puddle the crude iron in reverberatory furnaces, and on sand bottoms. By your permission I will read Mr. Cort's process:—A common reverberatory-furnace, heated by coal, is charged with about $2\frac{1}{2}$ cwt. of half-refined gray iron. In little more than half an hour the metal will be found to be nearly melted. At this period the flame is turned off, a little water is sprinkled over it, and a workman, by introducing an iron bar, or an instrument shaped like a hoe, through a hole in the side of the furnace, begins to stir the half-fluid mass, and divides it into small pieces. In the course of about 50 min. from the commencement of the process the iron will have been reduced by constant stirring to the consistence of small gravel, and will be considerably cooled. The flame is again turned on, and the workman continues to stir the metal, and in 3 minutes time the whole mass becomes soft and semi-fluid, upon which the flame is again turned. The hottest part of the iron now begins to heave and swell, and emit a deep-blue lambent flame, which appearance is called fermentation; the heaving motion and the accompanying flame soon spread over the whole, and the heat of the metal seems rather to be increased than diminished for the next quarter of an hour. After this period the temperature again falls, the blue flame is less vigorous, and in a little more than a quarter of an hour the metal is cooled to a dull red, and the jets of flame are rare and faint. During the whole of the process the stirring is continued, by which the iron is wrought to the consistence of sand; it also approaches nearer to the malleable state, and, in consequence, adheres less to the tool with which it is being worked. During the next half-hour the flame is turned off and on several times, and a stronger fermentation takes place; the lambent flame also becomes of a clearer and lighter blue, the metal begins to clot and become less fusible and more tenacious than at first. The fermentation then by degrees subsides, the emission of blue flame nearly ceases, the iron is gathered into lumps and beaten with a heavy-headed tool; finally the tool is withdrawn, and the aperture through which the iron was worked is closed, the flame again turned with full force for six or eight minutes; the pieces thus being brought to a high welding heat are withdrawn and shingled, etc.

* Read at the Cleveland Iron Trade Foremen's Association.

Although the above process made good iron, it had a very good metal to start with, well cleared from many of the impurities which we have to contend with now. But much of the iron was spoiled because of the inability of the workmen to regulate the action of the iron on the bottom of the furnace, it being formed of sand, which drained off the oxide, which was also detrimental to puddling. The next improvement on Mr. Cort's process was the substitution of iron bottoms to the puddling furnaces; and hereby the liquid bath of the oxide is retained by the iron, although the author of the iron bottom says it was the principal aim of his invention to work the iron in a bath of cinder; in fact, to boil it in a similar manner to the old process in charcoal fires. This part of the business was never carried out till Mr. Joseph Hall, of Bloomfield, Tipton, Staffordshire, brought it into practice. Mr. S. B. Rogers, who was the inventor of the iron bottom, never received much notice till his last years, when he received some gratuity from several of the Welsh ironmasters, but his work still stands, and to all appearances will be a lasting monument of his usefulness, although named "Mr. Iron Bottom."

You will here see that puddling has arrived at its present condition by slow stages, and improvements are being tried continually; but the elementary principle of puddling must be embodied in any scheme for the manufacture of iron, if it is to be a success. This is the process I have to treat with to-day, and it is performed as follows: The furnace is the reverberatory principle, the hearth at the bottom about 2 or 3 in. thick, and around, about 11 in. high, is coated with good oxides. When your furnace is hot enough to charge throw in your cinder or oxide which are found about your hammers or rolls; next charge the iron on the top of the cinder, the aperture of the furnace is closed, and the flame is put on. The charge is then melted in about 30 min., but during the melting the workman, with his rabble, breaks up the metal as it softens, and keeps it off the bottom. When the iron is sufficiently clear the damper is closed, which cools the surface and checks the iron from becoming too hot, and surcharges the furnace with carbonic oxide, which prevents the iron from throwing off its carbon till the whole mass of metal begins to heave and rise; the damper is withdrawn, and the flame put on; the iron is in a state of effervescence or boiling, as it is termed, and the whole of the exertion of the workman is required here to keep the msss well open with the rabble, so that the carbon combined with the oxide may freely escape. The fire upon the grate must be kept solid, and the flame full in every part of the furnace, because any free air passing through the furnace attacks the iron as it begins to come into its mature state, as it is called.

It is at this stage of the process that each granule of iron takes up a fresh existence. The boiling of the iron must be forced as much as possible to its issue to keep the iron from clotting before the carbonic oxide is burned out. It is also at this point that the cinder, with all its impurities, leaves the iron; hence it is necessary to keep the iron up, so that it shall be well wrought, and free from all deleterious substances. If the iron is not well boiled it falls into a crude or raw state to the bottom of the furnace, and if this be the case it is all but impossible to make wrought-iron of it afterwards. The iron being dropped, it requires the furnace still to be kept full of flame of a hot clear nature, but suited to the temperature that the iron will stand. The iron is now turned over from one side of the furnace to the other till it is sufficiently heated all through to adhere together, when it is formed into lumps, and taken to the hammer, and shingled and rolled into puddled bar. At this point it should be stated that although heat, especially a high heat, such as Bessemer attained during his decarburization process, is of the highest value, yet it should be borne in mind that any separation which takes place after the boiling ceases is only undoing what is already accomplished—the cementation of particle with particle by the combination of oxides. My opinion is this, that a chemical action has taken place before the iron is dropped, and this is where welding commences. That should never be disturbed, for all the carbon that is not required in the iron ought to be burnt out before the iron is settled down. The following is an analysis of the pig-iron previous to and after the Bessemer process:—The pig 1.012 bar, after 1.102; 2d, pig 1.090, after 1.960.

For the further guidance of those who

take an interest in puddling, I have drawn up a few rules which must be attended to when quality is required:—1. Thoroughly melt your charge. 2. Keep it in the melted state some little time. 3. Add carbon by lowering the damper. 4. Keep the fire well up while the iron is boiling, and work well every part of the charge, so as to bring about a thorough union of the iron and cinder. 5. Lower your damper proportionately to the temper of your iron, ball up, and carefully prevent the air or fire-oxygen from passing through the furnace, for it will burn the charge. Inattention to this is the great cause of bad iron. And I now beg, in conclusion, to draw your attention to the analyses and tests of samples of puddled bar made from No. 4 Cleveland pig-iron, which have been brought about by adhering to the above whilst puddling. The hardest of the samples stood a strain of 38 tons to the square inch. B, the softer, stood 38.8 to the square inch. Now, as phosphorus is generally supposed to be the cause of the Cleveland pig not making a bar of ordinary strength, it was an anxious part of the business to know when it is taken out by the process of puddling, there being a suspicion that the mischief is done by the burning of the iron when it is dropped, rather than by the phosphorus. Besides, Dr. Percy says that the elimination of the phosphorus of iron is a problem of the highest practical importance, and that his opinion is that it comes away during the time the iron is sweating while being formed into lumps. It was necessary to try and find when it did escape. During the Bessemer process, which is similar to the boiling before mentioned in puddling, the analysis of the iron gives more phosphorus than the original pig-iron, and his iron was taken out before it had a chance of sweating. After-boiling shows only slight traces of phosphorus. Therefore it must eliminate at some stage previous, which must be during the melting. It must escape as phosphoric acid among the cinder, which is oxide.

From the Darlington Iron Company, Albert-hill Iron Works, Darlington, to Mr. R. Lester, forge manager, etc., Messrs. Hopkins, Gilkes & Co. (Limited):—"I got your sample bars to-day, but cannot think they are made from Cleveland iron only. I tested them very carefully at my leisure time, and find these extraordinary results to be from common stone. You will favor me with particulars, perhaps this next week. Test, etc., as below:—

"No. 1 bar = .88″ $\times$ .80″ = .7040″; broke at 25 tons; carried 24.5; = 34.8 per sq. in.

"No. 2 bar = .88 $\times$ .80″ = .7040″; broke at 25 tons; carried 24.5; = 34.8 per sq. in.

"Reduced in section at breaking part to .82″$\times$.74″ =. 6068″.

"Yours truly, C. THOMPSON."

"Sample marked 'A soft'—phosphorus, slight trace. Sample marked 'B soft'—phosphorus, trace.

"HERBT. CROSSLEY."

After the reading of the paper, a very interesting and animated discussion took place upon the different processes which iron underwent during puddling, in which Mr. Hopkins and Mr. Hill, of the Tees Iron Works; Mr. Thomas, of the Acklam Refinery; and Mr. Platts, the secretary, took a prominent part. Mr. Hopkins thought it very desirable to continue the experiments that Mr. Lester had made with pure Cleveland iron, and he hoped that other firms in the district would also make experiments in the same direction, with a view of carrying out the objects of the Association—the practical discussion of such papers. Mr. Thomas moved the adjournment of the discussion until the next meeting. The Chairman proposed a vote of thanks to Mr. Lester for his interesting paper, and stated that on Saturday next the session would close by an excursion to the Eston Mines.

THE policy of harmonious working between the Grand Trunk of Canada and the Great Western of Canada line has been advantageously established; the continuous decline of the American gold premium still further promises to benefit the position of the Company. During the current year improvements effected in the rolling stock are likely to increase the traffic, and the progress of construction of the intercolonial line is expected during the coming summer to lead also to new business.

THE railway between Bombay and Calcutta has been opened for through traffic.

GUNS VERSUS TURRETS.

From "The Engineer."

The policy pursued by successive Admiralty Boards in dealing with what is known as the turret question, has been so exceptional that it can hardly have failed to attract the attention of every one interested in the construction and armament of our own and other navies. For many years the British Government positively refused to use turrets in any shape or form, and it was only under a severe pressure of public opinion that Captain Coles was allowed, ultimately, to apply his inventions to the Royal Sovereign. This ship was, in a sense, a success, and the nation by degrees acquired possession of two or three other turret ships of small size, two of which, the Scorpion and the Wyvern, are anything rather than successful. At last the Captain was laid down, and Mr. Reed, apparently grown tired of designing and building broadside ships, gave us the Monarch, and proposes to give us the Devastation, etc. ; and it is by no means impossible that for some years to come all our new men-of-war will, in some shape or other, be fitted with turrets on which they can rely for the protection of their guns and crews. Far be it from us to reopen any question concerning the relative merits of the broadside and the turret; we have a very different object in view in penning this article.

The tax-payers of England have never refused to place at the disposal of the Government for the time being large sums of money to be used in carrying out experiments in gunnery, or the construction of shields, forts, or even ships. At Shoeburyness almost every conceivable form of target representing a portion of a ship's side, or the wall of a fort, has been tested over and over again by every conceivable kind of gun, shot, shell, and powder. The lessons taught by these experiments are, beyond question, of enormous value. To them, indeed, we are mainly indebted for the possession of the best guns and the best armor-plated ships in the world. It is to be observed, too, that we have never adopted any invention of importance in guns or armor without first testing it elaborately, patiently, and for the most part fairly, with one exception, and that exception is the turret. It is possible that some good reasons can be brought forward to prove that it was unnecessary to test turrets with the fire of heavy guns, though all the other forms which armor can assume have been fired at over and over again; but if such reasons exist, we confess we know nothing about them. How is it that no complete turret with its turning gear, etc., has been put up at Shoeburyness and fired at till it was destroyed? We may be told that the experiment would have been too costly. This can hardly be the reason, because enormous sums have been spent in the construction of casemates and shields without the least hesitation, and the price of a turret would have very slightly augmented the annual expenditure on experiments, provided the testing of a few shields had been postponed. Of course it is impossible to test everything at once, and we may be told that in a little time the testing of turrets will begin ; but we submit that the proper time to test them is before, not after, their extended adoption by the Admiralty. The moment it was decided that we should have turret ships it should also have been settled that shields and casemates should give way for the moment to the new scheme. Instead of this, however, we find that enormous sums have been and are about to be spent on a system, the suitability of which to its intended purpose has never been practically tested by the Government. If it be indispensable that shields, and sections of broadside ships, should be tested, surely it is equally essential that turrets should be experimented upon. The chief constructor will not put a belt on one of his ships unless he knows from past experiment what that belt may be expected to do in maintaining, under fire, the efficiency of the ship on which it is bolted. But he has no hesitation in fitting a turret to the same ship, about which, turret experiment tells him nothing whatever. It is nonsense to say that the belt is only tested because the testing does not cost much. If the test be required at all it should be carried out, whether it costs much or little. If it is only carried out because it costs little, then that little is so much money wasted.

Of course, the answer to our arguments is that there is so much in common between a turret and a ship's side that when we test the latter we really test the former; and also that the turret system has been tested—first, at the time that Capt. Coles brought out his cupola; secondly, in actual warfare, in America and elsewhere, and again on board the Royal Sovereign, against one turret of which ship three rounds were fired from a 300 lb. rifled $12\frac{1}{2}$ ton gun, on the 15th of June, 1866, since which date—that is to say, within the last four years—notwithstanding our rapid advance in the construction of guns, no shot has been fired within the shores of England at a turret.

Now, in reply to these arguments, we submit, firstly, that although there is a great deal of resemblance between a section of a ship's side and a section of a turret, there is also a great deal of difference. A difference not nearly so great between 2 targets has, before now, secured the testing of each independently of the other. The argument cannot be pressed without charging the authorities with inconsistency, and we are disposed to think it never is pressed at all. The great point made by those who hold that the practical testing of the turret system is unnecessary is, that the Americans have tried the system fully, and that we have fired at the Royal Sovereign. If it could be shown that the results of those tests were conclusive, and in favor of the turret, we might rest content to admit that the no-test party had made out a very good case; but, in point of fact, the experience of the American War tells heavily against the turret system. The light guns of the Confederates disabled turrets in all directions. Mr. Eads, of the U. S. Navy, who was practically engaged in the construction of monitors for years, has recently published a letter most damaging for the advocates of the system, the fullest corroboration of which is furnished by official reports with which we are familiar. The experiment with the Royal Sovereign was precisely similar in character to that tried by Don Quixote with his helmet. The first shot went through the port, smashing the dummy gun to splinters. Had it been a shell instead of a shot every man in the turret would have been killed; of course, if a real gun had been there instead of a "quaker," the shot could not have got in; but then, how about the gun? Would it still have been serviceable? Another shot glanced, as it was not well aimed, and the third lodged in the backing. Had it been a shell, it would have ripped a great piece out of the turret. There is very little doubt that one 300 lb. shell fired subsequently, and striking fair, would have left the turret useless, but the shell was not fired. Every scrap of evidence available goes to show that the turret system, although possessing many admirable qualifications for warfare, is very far from having given results so satisfactory that it may be accepted as a whole without further experiment. On certain points in particular, information is required. If a shell struck a turret low down, and lodged in the backing, would it, or would it not, jam the turret by driving downward and outward a portion of its walls? If a 600 lb. shell passed through the breastwork with which Mr. Reed protects the bases of his turrets in the Devastation, etc., and exploded in the intervening space, what would be the result? How about the effect of shells dropped by vertical fire from rifled mortars into the same space? These questions are but a few of many which may be asked, and to which no answer can be given except that American experience proves that the results would be serious, if not disastrous, but that there is some ground for thinking that, after all, not much harm would be done. We are the last to advocate useless expenditure, but we hold that a moderate sum of money should as soon as possible be devoted to the construction and testing of a turret embodying all the latest improvements. Even if it were decided to construct this turret of only one-half the full size, reducing the attacking power in the same proportion, a great deal might be learned, although the experiment would not be quite so satisfactory, for obvious reasons, as it would be if carried out with the best turret and the best gun that England can produce.

The Honduras Railroad is still progressing favorably, and it is believed that the section of road between Cortez and Santiago will be finished before the end of the year.

THE IRON AND STEEL INSTITUTE.

From "Engineering."

Amongst the numerous scientific associations with which engineers are professionally connected, the Iron and Steel Institute is one of the most recent origin. The short history of this society, however, is one of considerable importance with regard to the general progress of industry in this and in other countries, and there can be no doubt that the Iron and Steel Institute has, in the short period of its existence, succeeded in taking its place among the first and most powerful scientific bodies in the United Kingdom. This is due not only to the number of its members, and the influential position which the greater part of them occupy in all the different manufacturing localities of this country ; but also to the great amount of practical experience at the command of the Institution for investigating and discussing questions of great practical importance, and to the enterprising spirit with which committees for scientific and statistical researches are appointed and endowed. All these, and many other minor points, are distinguishing features which cannot fail to produce the most important and beneficial results upon the progress of iron metallurgy, and of all branches of industry and engineering, while by a necessary and just reaction they tend to raise the position and estimation of the Iron and Steel Institute in the eyes of the public. At the meeting which was held at the Westminster Palace Hotel recently, a committee was appointed to report upon the question of mechanical puddling ; while another committee was intrusted with the task of reporting upon the distribution of hematite iron ore in Great Britain. These investigations of subjects of such vast importance cannot fail to advance materially the position of the iron and steel trade in general, and the council of the Iron and Steel Institute deserves congratulations for having given the impulse to these investigations.

The technical questions under discussion at the last meeting comprised a subject which at present stands very prominently before the minds of iron masters and mill managers, namely, the question of reversing rolls as compared with double sets of rolls or "roll before roll," as this latter arrangement is generally termed. This subject formed the main point of the discussion upon the paper on improved machinery for rolling rails, read by Mr. Menelaus, of Dowlais. Reversing at high speed, say at more than 40 revolutions per minute, has for a long time been considered as an absolute impossibility by practical men. The momentum of the mass in motion, and particularly that of the heavy fly-wheel by which the constructors of rolling mills were accustomed to "get over" the insufficiency in direct steam power which they had provided for the work of the mill, were the well-known causes which actually rendered reversing at high speed impossible in past days. Mr. James Nasmyth, the well-known inventor of the steam hammer, made the first step in the direction which has been so successfully followed by Mr. Ramsbottom, of Crewe, and which resulted in the modern high speed reversing mill. Mr. Nasmyth removed the fly-wheel and suggested the reversing of the engine by means of the link motion. This idea, supplemented by Mr. Ramsbottom's ingenious reversing gear, produced what is now one of the best and most successful types of rolling mills in existence. Messrs. Tannett & Walker tried to arrive at a similar result by a reversing gear in which the transmission of power is effected by a friction clutch, which can be reversed with great facility and without causing any sensible shock, by means of a simple steam or hydraulic piston. The advantages and disadvantages of these reversing rolling mills, form a subject upon which opinions justly differ. The fact that the momentum of the large masses must be destroyed or overcome each time the machine is reversed, is a disadvantage which cannot be denied nor altered, however gently this absorption may take place, and however carefully all sudden jerks and concussions may finally be avoided. Reversing, therefore, undoubtedly means loss of power. On the other hand, the reversing rolling mill, when compared with the ordinary two-roller mill, saves nearly one-

half of the time in rolling forward and backward when compared with the "three roll mill," or with the well-known Dowlais mill, invented by Mr. Menelaus about 12 years ago. The reversing rolling mill saves a considerable outlay for additional rolls, or, what is still worse, additional length of rolls, and it also avoids the necessity of raising and lowering the end of the bar by the height of the diameter of the rolls after each passage through the rolls. A new form of rolling mill by Mr. Brown, was exhibited at the meeting by a model, this mill consisting of a double pair of rolls driven in opposite directions, and in which the working grooves of each pair of rolls are placed opposite to blanks or large recesses in the other pair of rolls. This mill has the drawback as compared with the Dowlais mill, which it most resembles, that it requires additional length of rolls to allow for the blank spaces or grooves. Compared with the mill "three rolls high," it offers decided advantages, and compared with the reversing rolling mill it presents the advantage of having a continuous movement in all its parts. From all the evidence brought to light by the discussion it appears that the reverssing rolling mill, without fly-wheel, and provided with a pair of horizontal cylinders reversing by the link motion, is the type of mill most in favor in our modern iron and steel works, and most likely to become the standard type of rolling mill for the future.

The question of blast furnace economy under the form of a discussion on the Siemens-Cowper stove, as modified and constructed by Messrs. Whitwell, again occupied the principal part of the time and attention of the Iron and Steel Institute. With regard to this question, Mr. Lowthian Bell has taken a prominent position before the scientific world by the extensive experimental researches of which he has recently given the results to the public, and upon which he has based the opinion that the limits of blast furnace economy derivable from the two causes, viz., capacity or height of furnace and high temperature of blast, have not only been reached, but actually exceeded in the Cleveland district, and that no material economy can be expected from further increments of these elements. This view is supported by many practical men in the Cleveland district, and in other parts of the country, while many other authorities dissent from Mr. Bell's views. The most energetic and zealous opponent of Mr. Bell's doctrines is Mr. Cochrane, who has tried to establish, by the experience of actual work, the benefits derivable by heating the blast and increasing the capacity of the furnace beyond the limits indicated by Mr. Bell. Mr. Cochrane shows, from actual experience, that he has effected a large saving in coke directly, and immediately upon increasing the temperature of the blast from 1000° to 1400°, and without changing any other condition of the work. Unfortunately for his cause, however, it appears that the furnaces upon which these experiments had been tried did not formerly work as economically as other furnaces in the Cleveland district, and that after having arrived at this relative economy Mr. Cochrane's furnaces showed about the same consumption of coke per ton of iron as the best managed furnaces in other iron works in Cleveland, which work with 1000° of blast as a maximum. Mr. Cochrane ascribes this to causes which certainly have no influence upon the question at issue, such as imperfect calcination and the general influence of alterations, new buildings, and innovations upon the economical management of materials. Another question which may still have been overlooked is the quality of the coke, which in comparing different works with each other may form an important cause of quantitative differences. So far as this discussion is concerned the question is, therefore, not solved yet, and it remains to be seen whether at some future day Mr. Cochrane, by further improving the economy of his furnaces, will force Mr. Bell to modify his theory, or if the scientific discoveries of Mr. Bell, and the practical conclusions deduced from them, will find in the future experiments of Mr. Cochrane a striking and important corroboration.

Some of the principal planters of Bom Jardim are promoting a scheme for a narrow-gauge extension of the Bahia and San Francisco Railroad, about 16 miles in length, from Alagoinhas into that district, which, if carried out, could not fail to be a valuable feeder to the railway.

THE METALLIC MINERAL RESOURCES AND PRECIOUS STONES OF RUSSIA.

From the "Mining Journal."

It is not generally known in England that the Russian empire is immensely prolific in metallic and other mineral resources; yet there are few, if any, substances known under these heads which are not found in some parts of the Czar's wide-spread dominions, which have been estimated by some as equal in extent to the great satellite which attends and cheers our world. It is not more than a century and a quarter since the Russian Government became aware of the presence of gold in the Oural and Oural Mountains, the only part of the empire then supposed to contain that precious metal. However, in less than half a century after, the people obtained in the washings in that district not only gold, but silver, copper, and some precious stones, particularly topaz; subsequently, rubies and carbuncles, so often discovered in the presence of gold, were obtained there.

The methods used to procure the gold from either the sands or the quartz were exceedingly rude, and the quantity, at first small, gradually increased up to 1820, when, with the yield of silver, the value was estimated at 20,000,000 of silver rubles (£2,500,000 sterling). Since then the increase has gone on more rapidly, new fields have been opened up, and now gold-bearing strata are found to stretch along the whole range of the Oural Mountains, from latitude 45 to 67 degs., in the northern slopes of the Altai, in the southern shoots of the same mountains, on the land near Irkoutsk, along the River Amoo, and in the Kirghis steppes.

In the Oural the gold gravel, or debritus, is not usually more than a fathom from the surface, and is often found 10 ft. thick. The gravel is covered with clay, above which is a soft peat, itself covered by the common soil.

The washings on the Amoo are seldom rich, and very large nuggets are uncommon anywhere, even in the Oural or the Kirghis steppes. It is reported that there are very extensive and rich sands in Mongolia, on the other side of the Russian territory, which the Imperial Government is anxious to possess. In Eastern Siberia the washings can only be pursued from May to September. Judges have not hesitated to proclaim that, on the whole, Russia is richer than Australia in gold. Silver is principally obtainable on the Altai, where an average of 60,000 lbs. annually is produced. It is not generally accompanied by lead there. Lead is, however, found in the Altai, and in nearly all the gold mining districts, but its discovery and working are not pursued with either spirit or intelligence, and the total yield is small. No doubt exists of large stores in all those ranges. Platinum is more eagerly sought, as the Government until lately used it in coin; for nearly half a century it has been obtained in moderate quantities in Nijni Tagil. During the last decade there has been less inquiry for it. Black lead, equal to that of the English mines, is found in large quantities in the Saian Mountains. The Oural Mountains, so productive of the most precious metal, produces nearly all the metals in quantities more or less considerable. Copper was worked time immemorial in several parts of Siberia, and in the Kirghis steppes, but nothing remains of those workings but a well-sustained tradition. Modern operations in quest of copper are little more than half a century old. The mines of Nijni Tagil and neighboring setts have acquired a great reputation. Nearly the whole eastern slope of the Oural abounds with this metal. It appears, however, that the yield of the percentage of both in ancient and modern times was very small throughout the extensive range in which the ore was found. The manufacture of copper in all parts of the empire where works exist is rapidly declining, in consequence of the fall in price of the metal and the large supplies from South America, and the inadequate supplies of wood for charcoal, the fuel employed in most of the districts where the metal is found.

The declension of iron manufacture in Russia is also obvious, chiefly from deficiency of fuel, and the great distance of the mines from the centres of commerce and civilization. The iron industry in Russia owed its origin to Peter the Great, and 150 years ago vast mines were wrought

and great works erected. The empire seems to produce every description of ore, and each in great variety.

In the Altai and the Oural vast masses of magnetic ore are found. There are various other directions where magnetic ore is found in smaller deposits. Very fine ore for the purpose of steel manufacture is extracted in several districts. Ordinary ores are much more abundant, and are discovered over a wider area of country. In the centre of Russia red oxide is the prevailing yield. One great advantage is that a deep iron mine is not known in Russia ; whenever the metal is found it is near the surface. It would be impossible to estimate the resource of the country in iron ; probably it exceeds that of any other country in the world.

Chrome and sulphur are also obtained there. Sulphur pyrites abound from the Northern Oural to Pensa. Tin, so much prized in England, has been found in several of "the Governments" of the empire, but is worked in none. Diamonds have been sought with much persistence, but no mines exist. In the North Oural they are not unfrequently picked up. A single emerald vein was discovered some years ago, yielding some of the finest specimens in the world, but through Government mismanagement and greed it has been lost sight of. The supply of jasper is exceedingly fine and abundant, literally mountains of it may be said to exist. The subject of the non-metallic mineral resources of Russia shall on some future occasion engage our attention, as also highly important and interesting.

COAL-BURNING LOCOMOTIVES.

From "The Engineer."

A complete treatise on the various devices which have been suggested, patented, or employed, to enable locomotive engines to burn coal instead of coke without smoke, would constitute a very bulky volume indeed. Yet the number of such devices in actual use in this country, and at this minute, is exceedingly small. Locomotive superintendents have apparently arrived at the same conclusion as many other thoughtful engineers, who accept the fact that while it is possible, under all circumstances, to burn coal without smoke, it is very frequently not worth while to resort to the appliances essentially necessary to securing this end. In plain English, it does not pay to prevent or consume smoke when the prevention or consumption can only be effected at the cost of loss of power, or by the use of complex and expensive boilers, fire-boxes, and smoke-preventing apparatus. In the neighborhood of the metropolis and large non-manufacturing towns our railway companies find it cheaper to burn a smokeless, or nearly smokeless, coal, than to resort to the use of a coal perhaps a shade less expensive, which can only be prevented from giving out clouds of smoke by great care, incessant attention on the part of the stokers, and the adoption of fire-boxes and boilers troublesome to make and costly to repair. One by one of all the so-called systems of coal burning are disappearing from our great railway lines, and the normal type of locomotive furnace of the present day is identical with that of a period when the general consumption of coal in locomotives was a thing yet undreamt of, with the addition of a brick or fire-clay arch, and a scoop deflector, supplemented by a steam blower in the chimney. The substitution of coal for coke in locomotive working dates back as far as 1837, when Gray and Chanter introduced modified grates. They were followed by Dewrance and a host of others ; and it is indisputable that very smoky coal indeed has been burned without causing any great annoyance to the public, by the use of various devices more or less complex. It must be borne in mind that the first locomotives ever worked, burned coal only ; but such locomotives as those of Blenkinsop, Trevithick, or Stephenson, constructed previously to the Rocket, did not convey passengers. They were worked, not before the public, but in comparatively isolated districts, where smoke was not regarded as an especial evil to be complained of ; and the substitution of coke for coal may be regarded as a refinement introduced to please the tastes of a totally

different race, at a period when every item of railway expenditure was calculated on a princely scale. As soon as it was discovered that the possession of railway shares did not necessarily augment a man's income, first steps in retrenchment commenced, and costly coke gave way to coal. No engineer ever doubted that as much steam could be made with coal as with coke in a given time—though some individuals, not engineers, entertained serious doubts on the subject—and the best endeavors of inventors were therefore confined to finding out and embodying in practice those conditions under which coal could be burned without smoke; and as the manner of many inventors is, they, as a body, always used the most bituminous coal they could get. The result was that smoke was kept down with difficulty in costly boilers. It remained for the present generation of locomotive superintendents to find out that the best and cheapest remedy for smoke is to burn a coal which only makes it in moderate quantities. No heavily smoking coal has ever yet been burned in locomotive fire-boxes without causing a nuisance, or entailing more trouble than it was worth; and so we find that in all locomotives of the latest type, with a very few exceptions indeed, the old-fashioned horizontal grate and approximately cubical fire-box is used, just as though coke was to be burned, a brick arch and a scoop being the only additions to an arrangement dating back to the year 1832. We believe it would be difficult to pick out half-a-dozen locomotives in England built during the last twelve months, and excluding the South-Western Railway, in which combustion chambers, step grates, steeply inclined grates, or midfeathers can be found. Where these things exist now, they are being done away with. For example, Mr. Martley, of the London, Chatham, and Dover Railway, has greatly modified the boilers of nearly all his heavy mixed engines of the "Swallow," "Stork," etc., class. These engines had Cudworth grates of great length and steep pitch, separated by a midfeather, the boilers being, for the most part, flush. These fire-boxes have been taken off and replaced with square, or nearly square, boxes of the old coke type, the outer shells rising above the boiler barrel instead of being flush with it. The side frames have been cut so as to bring up the cross tail-plate close to the tires of the trailing wheels. The size of the foot-plate remains unaltered, but the whole engine is shortened by about 15 in. The effort, æsthetically considered, has been to convert perhaps the ugliest engines in England into very good-looking locomotives; while, as regards coal, the change has been attended by an immediate and remarkable diminution in the fuel accounts. If anything, the engines make less smoke since the alteration than they did before, even with the same coal. We find it not easy to doubt that other locomotive superintendents will follow Mr. Martley's example.

It may be taken as proved that no locomotives exist which do not give out smoke if a bituminous coal is burned on their grates. It is true that such coal can be burned in many engines without much, or perhaps any, smoke; but in practice this end is never secured. To burn bituminous coal without smoke under any circumstances requires more care and skill than can be expected from an ordinary stoker; and it is also essential that the engines should be moderately loaded. The great principle of all smoke-burning furnaces is to secure intimate mixture of the gases with a sufficient quantity of air; but this requires time, or space, which may be taken as equivalent terms. It may be quite possible to burn coal without smoke at the rate of 20 lbs. per ft. of grate per hour, when it would be impossible to burn double the quantity without producing dense masses of smoke; but a stoker firing an engine struggling with a heavy load will do all he can to burn as much coal as he can in a given time. The result may be seen on any North-country railway. As mitigants of smoke, the brick arch, the scoop, and the blower are as efficient as any more complex and expensive devices; and as the best result to be had in practice is apparently only a mitigation of the evil, whether the smoke-preventing devices are costly and complex, or cheap and simple, cheapness and simplicity are naturally preferred. And, after all, is the production of some smoke such a very serious evil? Where smoke in any form is intolerable, or, at all events, untolerated, it seems there are but two ways of getting rid of the nuisance. The first is to burn coke; the second to use a smokeless coal.

MODERN ARCHITECTURE IN WESTERN INDIA.

From "The Building News."

Sir Bartle E. Frere, K.C.B., G.C.S.I., delivered a lecture on this subject at the Royal Architectural Museum, Tufton street, Westminster, on Wednesday evening, the 26th ult., Sir Walter James, Bart., in the chair. After entering at some length into explanatory remarks concerning the ancient architecture of India, Budistic, Brahminical, and Mahometan, the lecturer proceeded to treat of the modern architecture of the empire. He said that when the English nation suddenly found itself the possessor of the great empire and of its great works of architecture, architecture in England was at such a low ebb that we could not realize what was essential to the progress of the art in India. It was difficult to describe the character of our early Anglo-Indian architecture; its only characteristic was extreme broadness—an utter absence of anything like distinctive features. This was only to be accounted for by the fact that we sent forth our representatives to receive and acquire the Indian empire at about the same time as we were building Red Lion square and the acres and miles of featureless streets, roads, and squares, and the nightmare churches so unlike anything which is dreamt of as a church, whether in a town or a country village. Our ancestors, in consequence, left no good architecture after them in India. An ordinary Indian station was as nearly as possible like a nightmare of umbrellas in brick and mortar. Were the materials brick and mortar, stone, or anything else, they were put together so as to afford shade and shelter, and nothing else. In Kurrachee, for example, it is impossible to conceive of anything uglier than the buildings of the place as carried out by the British officials (of whom Sir Bartle was one). In Kurrachee there are nothing but straight roofs, projecting on each side, and giving plenty of shade and shelter, mounted upon a certain amount of bricks and mortar, or timber; but of anything like architecture there was, up to the time he left the place, none, although there was a population as large as that of Bath. Perhaps it might be said: "But we have heard of a certain 'city of palaces'—Calcutta; surely there are some palaces there?" Well, although he was travelling out of Western India, he could only say that the "palaces" of Calcutta were palaces of brick and stucco, built on a foundation very much resembling that of our own good town of Sheerness; a hundred years hence, probably, the English people would not look with very great pride on the "City of Palaces," because the materials employed are not such as any architect would use for architecture of a high order or intended for posterity. In Bombay things were little if at all better. The Government House there was a Jesuit church, and whatever feature it may possess of architectural grandeur is certainly not due to the British Government. At Madras there are one or two very good buildings connected with the Government, but architecturally they are such as would be found in almost any second-rate country town in England, and their pleasing effect is due to a very beautiful variety of plaster which is afforded by the corals and shells of the coast. The whole of what the English Government has done for the adornment of the capitals of India may be summed up by saying that very few public buildings have been erected which would be considered in any seaport town in this country to be above ordinary merit. But while this is true of the Government, there is much in all the Presidency and chief towns of India of great architectural interest, due, as is the case in most parts of the world, and under all governments, to the people themselves. It has no more been in our power to impress permanently upon the architecture of India any feature of our own than it has been in the power of any government in Europe to give an architectural bias to what is built by the people over whom that government rules. Of course in a long series of ages much may be done by a government, and as we see in France, a government may, by power steadily and sternly applied during a whole generation or two, produce an amazing result on one large city; but what is likely to be the verdict of posterity when they contrast the modern architecture of Paris with the works of the great architects who preceded our own age?

There were many who would lament, even for the good results that had been achieved, the destruction of much that was interesting in old Paris ; and where were the buildings in modern Paris that could compare with the cathedrals and chateaux of France ? and will not these cathedrals and chateaux be speaking architecture to posterity when Paris has ceased to be regarded as more than immense mountains of stone ? We were very apt to decry our own city of London as inferior to the capital cities of the despotic powers of Europe, but in London was to be seen the impress of an architecture that grows from within—an architecture that expresses what the people think, and feel, and mean, and not what they are told to think, feel, or mean, as was too often the case in the despotic capitals of Europe. The lecturer then went on to describe the state of Indian civilization at the time the Empire came under British rule, and referred to the state of Bombay when Mr. R. W. Crawford (now M. P. for the city of London) was Chairman of Justices in that place. Mr. Crawford instigated great reforms. He found the city without good water to drink, without drains to carry away the refuse, and without any of the conveniences of modern civilization except a few good roads ; and he proceeded to supply the city with water, and to construct good drains, in which work he was ably seconded by the whole body of English and native Justices, and received great assistance from the Royal Engineers, Mr. George Clarke, an engineer in Bombay, and Mr. Conybeare, an architect, who erected the first church worthy of the name in India. This church, however, owes some of its best features to Mr. G. G. Scott, who was appealed to to give a design for a memorial church to those who fell in the Affghan wars. He gave a very beautiful design, but one too elaborate to be carried out for the money ; thefore another design by Mr. Conybeare was substituted. The erection of this church gave an immense impulse to the spread of good architecture in India, and much of this impulse was due to two members of the Museum, Mr. T. Roger Smith, and Mr. Trubshaw. The latter gentleman went out to Bombay at a time when there was a great influx of wealth into the city, and when many men who were in trade or business found themselves possessed of very considerable means, and the native merchants used this unexpected wealth in a manner that would have done honor to any community of Englishmen. The lecturer concluded by dwelling at some length on the public-spirited liberality of the Parsee and other native gentlemen, and on the influence which their munificence has had on the architecture of the great cities of the Empire. He referred to the labors of Mr. Parris, Mr. Morrisey, and Mr. Emerson, who had, he said, all followed in the steps of Mr. Trubshaw in endeavoring to found what he believed to be an indigenous school of Anglo-Indian architecture, as extensive and as distinct as the pure Hindu and Mahometan schools of former days ; and he believed that if God granted us grace to hold the empire of India for a few generations longer, we should leave behind us in architecture, as in other respects, such marks of our government as posterity would not soon forget.

The railway line from Moscow to Tarostavl, or Yerastavl, was opened lately from one end to the other. The Government of Tarostavl produces linen and timber. The present railway company demands the concession of a branch from Makarovo to Kustrama. Moscow is now the terminus of six great railway lines, *i. e.*, Nicholas Line to St. Petersburg, 634 kilos., N. W. (393 miles) ; line to Taros–tavl, 277 kilos., N. E. (172 miles) ; line to Neejnee-Novgorod, 430 kilos., E. (267 miles) ; line to Riazan, open now to Tambof, 471 kilos., S. E. (292 miles) ; line to Kursk, and line from Kursk to the Sea of Azof, 1,327 kilos., S. (823 miles) ; line from Kursk to Kier and Odessa, 1,300 kilos., S. W. (806 miles).

M. Quenault, an indefatigable observer of the encroachments of the sea on the coast of France, writes from Montmartin-sur-Mer, to the effect that he has discovered below Hauteville-sur-Mer, near the Maulieu rock, remains of a submerged forest. These remains are covered by 12 metres of water at spring tides. The oaks only have preserved their hardness, the other woods being soft, like a paste, although they have retained their color and bark. He dates the immersion about the eighth century.

SMALL PORTABLE ENGINES.

From "The Engineer."

The Royal Agricultural Society will, we understand, give special prizes this year for the best and second best engines in a class which has hitherto hardly ever received either prizes or notice. This class embodies all the little engines with vertical boilers fixed on cast-iron bases or pedestals, which are to be counted by the score at every agricultural show in the kingdom. How they are to be tested we are unable to say exactly; but it is certain that if the consumption of fuel is to influence the decision of the judges, it is quite possible, as things stand at present, for any person possessing a little energy and knowledge of the subject, to win all the prizes that may be offered without the least difficulty. As we should infinitely prefer a good competition to a species of race in which one or two makers are first and the rest nowhere, we think it well to call the attention of our readers in general to the subject, and to bring to their minds a few of the conditions which are essential to the success of any engine competing for a prize, be it medal, or money, or honorable mention.

Out of the mining districts it is impossible to find any type of steam machinery more imperfect in every sense than the little 3 and 4-horse vertical engines, which command a large sale because they are cheap. The engines are all but invariably made to sell; and yet by a strange perversity, manufacturers—we can hardly with justice say engineers—prepare their designs without any true appreciation of the proper method of turning out cheap work. It does not follow that because an engine is cheap it must therefore be nasty; but by far the larger proportion of the little engines under notice are nasty. They are bad in design, fearfully and wonderfully made as regards workmanship, unpleasing to the eye, and certain to give dissatisfaction to any luckless wight unfortunate enough to invest his money in one, and knowing all the while what a moderately good engine of the kind should be. Now, as a matter of fact, there is no reason whatever why a vertical engine and boiler of, say, 4-horse power, should not be pretty to look at, good to go, fairly economical in the consumption of fuel, and very moderate in price notwithstanding. The first point to be considered is the general arrangement. For the most part, that type of engine in which the cylinder is inverted and the crank shaft carried by a saddle bolted to the lower end of the boiler, is preferred. In preparing the design for such an engine the first point to be considered is the boiler. If this is to be moderately economical, something more than a fire-box and uptake put into an outer shell is needed. We may either use Field's tubes, or cross tubes, or tubes springing from the side of the fire-box, and running up to the crown plate, or vertical fire tubes, or a Thompson pot boiler; but whatever type is selected, care should be taken that sediment shall not accumulate in dangerous or objectionable places. It is urged by many engineers against the Field and other boilers with hanging tubes, for example, that although in a boiler kept always at work no deposit of sediment can take place in the tubes, yet that in boilers worked during the day only, and allowed to cool at night, a very considerable crust forms on the tubes. How far this may be accurately true we shall not pretend to say; the statement is reasonable and consistent with general experience. Large cross tubes do not give enough surface, and they become furred, and cannot be cleaned; vertical fire tube boilers with short tubes are desperately uneconomical. The Messenger boiler, already illustrated in our pages, appears to be one of the best of the small boiler types with which we are acquainted; and Mr. Frazer, of Bow, is now bringing out another vertical boiler, from which, we think, he will obtain good results. In any case, the vertical fire tube boiler, the boiler with one or two cross tubes, and the boiler with fire-box and uptake only, must be beaten at Oxford. They have not the ghost of a chance, for the simple reason that nothing is more easy than to design a boiler which will excel them in every point but one, viz., cheapness.

No matter how good, by comparison, the boiler may be, it will fail to give good results at Oxford if it be worked in conjunction with a bad engine. But, after all, the principal point to be attended to

is the keeping of the cylinder hot. Who ever saw one of the little engines we speak of with a jacketed cylinder, or a cylinder enclosed in the hot air escaping to the chimney, or fitted with a superheating pipe? These things are assumed to cost a lot of money, and, are therefore left out; although we may see 2 cwt. of good cast-iron put into the saddle, where ½ cwt. would do better, and similar mistakes made by the score. It is undoubtedly true that to cast a cylinder with a jacket will cost a little more than to cast it without; but the patterns once made, it will not cost much more, and the advantage will be found enormous. We have very little doubt that jacketed cylinders will compete at Oxford with unjacketed, and woe to the latter in such a case. Besides jacketing there are one or two other devices which may be used to the same end with advantage. Why should not the feed-water be heated in the chimney? Why should not the steam be moderately superheated in the same place? Nothing, again, would be easier than so to dispose of the waste steam that it should draw a moderate quantity of heated air into a case of sheet-iron surrounding the cylinder in a way which would effectually prevent condensation in the cylinder without endangering its face or that of the slide valve. In a word, there are a thousand and one ways in which the vertical, so-called, portable engine, may be improved.

We sincerely hope that it will not be found when the tug of war comes that all the improvements have been effected by a single firm.

EXPERIMENTS ON THE RESISTANCE OF IRON AND STEEL.

By A. MOHLER.

Translated from "Polytechnisches Centralblatt."

Under this title the author publishes the results of experiments, made with the greatest care during a period of 12 years, which verify his theoretic views upon the laws of resistance of these materials. We lay before our readers the author's statement of the laws and their consequences. He says:—

The rupture of material is the consequence of repeated vibrations, none of which reach the absolute limit of resistance. The differences of the tensions which limit the vibrations are therefore proportional to the disturbance of cohesion. The absolute magnitude of the limiting strains is effective only as it diminishes the difference attendant upon increased strain, which difference causes rupture.

The tensions and compressions affecting the same fibre are considered as respectively positive and negative; so that the difference of extreme strains is equal to the greatest tension *plus* the greatest compression.

The following exhibit of the results of experiments illustrates the effect of this law of resistance. With reference to resistance to bending or tension, vibrations may occur within the following limits of safety for each (German) square inch of section.

Iron	Between	+ 160 ctr.	and	− 160 ctr.
	"	+ 300 "	"	− 0 "
	"	+ 440 "	"	+ 240 "
Axengusstahl.	"	+ 280 "	"	− 280 "
	"	+ 480 "	"	0 "
	"	+ 800 "	"	+ 350 "
Ungehärtelern federgusstahl.	"	+ 500 "	"	0 "
	"	+ 700 "	"	250 "
	"	+ 800 "	"	400 "
	"	+ 900 "	"	600 "

With reference to resistance to shearing:

Axengusshtahl.	Between	220 ctr.	and	− 220 ctr.
	"	380 "	"	0 "

Of course the greatest fibre-strain actually applied is always less than the absolute breaking limit. The following are presented as immediate results of this law:—

Those parts of construction which act positively and negatively, as piston-rods, walking-beams and the like, must be stronger in the ratio 9:5 than those which are strained in only one direction, as beams, bridges, roof-timbers, etc.

In determining the resistance of bridges and large trusses the weight of the structure, since it forms an absolute constant minimum load, may be left out of

account, provided the sum of the effect of proper weight and load does not pass the limits of elasticity.

In the case of car-spings the vibrations are between limits whose difference is quite small compared with the maximum tension; hence the coefficient can be taken larger than in ordinary cases if the steel does not suffer an inch strain of more than 800 ctr. It often reaches 900 to 1,000 ctr.; and with good steel a further increase is possible.

Those parts of boilers which are not exposed to the fire, if of cylindrical form, are subject to but slight vibrations, which are caused by the variation of the tension of the steam. Hence a greater strain is allowable than has been generally applied; but in the parts exposed to the fire, not only the waste by burning, but also the motion of the molecules due to the varying temperature must be considered. It is not improbable that the continued movement of molecules, caused by heat, acts to destroy cohesion, just as vibrations caused by other forces act.

The effect of strain is entirely different, if it is constant and static, from the effect when it is variable and productive of vibrations. It is also important to consider whether a structure is intended to serve a purpose for a limited period, or to stand for an indefinite time. It follows that like factors of safety do not suit all constructions. In every case two factors are necessary; one, which determines the ratio of absolute breaking strength; another, which fixes the ratio to the vibration that induces rupture by indefinite repetition.

The coefficient of safety should be taken large enough in comparison with the absolute breaking strain, that it may compensate for want of homogeneity of material. For this the factor 2 is sufficient. Material requiring a larger coefficient in this respect should be rejected. The limits of elasticity have not thus far been considered, and it must be left to the judgment to determine between what limits continuous deflection is allowable. A single loading, preventing further deflection, can do no harm, if it does not approach the breaking weight. In large structures it is a general rule that the limit of elasticity should not be passed.

As a coefficient of safety for repeated vibration, 2 is in all cases sufficient, and in many cases is higher than necessary.

As a result of his experiments the author gives the following table of inch-strains for permanent structures:

For wrought-iron,

Strained in both directions......80 ctr.;
" " one direction,
total strain........180 ctr.

of which not more than 150 ctr. should be due the variable load. If the constant strain is less than 30 ctr. the permissible total strain must be proportionally less.

For unhammered cast-steel,

Strained in both directions.......120 ctr.
" " one direction, greatest
total strain........330 ctr.

of which not more than 220 ctr. should be due to the passing load. The constants apply to pieces of uniform section.

Experiments with spring-steel show that car-springs should not be loaded to three-fourths of the breaking resistance, if the play of the spring is small in proportion to the entire deflection. With a constant strain of 900 ctr. a play of between 900 to 1,200 ctr. is allowed.

An important addition to the resources of spectrum analysis has been made by Zöllner's invention of a reversion spectroscope, by which extremely small changes of refrangibility, and consequently comparatively slow motions of a star or sun-flame, can be detected. It consists of a spectroscope in which, by reflection, the spectrum of a source of light can be superposed above a reversed spectrum of the same source; so that if a white flame containing sodium be viewed, there will be seen in the upper part of the field a sodium line with the blue end of the spectrum on the one side, and underneath it a sodium line with the red end of the spectrum on the same side. The two bright lines may be made to coincide exactly by an adjustment; and if any change in refrangibility takes place, the motion of the line is doubled, and is also more exactly measured, because it is referred to itself as a standard.

All the telegraphs in Egypt under direction of the Government, are worked on the Morse system.

THE FLEET OF THE FUTURE.*

By MR. J. SCOTT RUSSELL.

From "The Mechanics' Magazine."

We live in times when revolutions pass so quickly, and carry us to results so little foreseen, that it is necessary to pause from time to time and see whither the race of events is tending, and consider whether our practice and policy in the past will serve us for the future, and whether it may not be wise to modify our plans by the altered circumstances in which we live—in anticipation of this institution ten years ago—and nothing can be more striking than the progress we have made in our ideas, and the revolutions we have gone through in that short time. We were then engaged in discussing this same question, and the great topic was no less than this—whether the fleet of the future should be iron or wood—ironclad or unclad. Who now dreams of returning to wooden men-of-war, to sailing fleets, to three-deckers? And yet no less an authority than Sir Howard Douglas broke many a lance with us ten years ago in a contest about the fleets of the future. These ten years have spoken and pronounced a verdict upon the past. There are few of us left now to argue that a combustible material is the best for the construction of an incombustible fleet. As you were then sagacious enough to take a far-seeing survey of the fleet of the future, which survey I feel satisfied has powerfully aided in giving a right direction to public opinion and public action in the consideration of the fleets of the last ten years, so I think it is wise now to look round and consider what the experience of this last ten years has taught us, and to look forward and consider the nature of the future ten years, and of the new conditions under which we shall henceforth have to plan and choose and act. Great events have changed the surface of the world in the past ten years. The union of remote continents by submarine telegraphs is a great event. The canal of Suez is a great event. The ocean of India is now steadily, though slowly, flowing into the Mediterranean; the current has been ascertained to be a steady one from the Indian Sea into the Mediterranean, and so into the Atlantic. That single barrier removed enables a steamship to sail from New Orleans, from New York, with a cargo of cotton for Marseilles, to unload there, and receive a cargo of manufactured goods for India, China, or Japan, and to continue with a cargo of tea, rice, and other Oriental products from Yokohama to San Francisco, thus performing the trip of 22,000 miles, equal to the circumference of the earth, without let or hinderance. That canal is a new element in the commerce of the world, in the intercourse of nations, in the wars of nations, in the civilization of the human race. The Pacific Railway across America is another great event. It makes the Americans masters of two sea coasts, gives them the commerce of two seas, and to us it opens up a short cut round the world. What events have we to meet in the next ten years? It is not hard to tell. Ten years more will cover the bottom of every sea with lines of electric telegraph. Ten years more will see the Isthmus of Panama cut through, and the Atlantic and Pacific Oceans made one. Right through the Suez Canal, all across the Indian Ocean, straight across the Pacific, home across the Atlantic; by this new canal a large steamship will be able to circulate freely round the world. I have here a plan of the canal to which I last referred, as now sanctioned by the American Government, and largely contributed to by the United States. It is to be made through the narrow part of the Isthmus of Darien, with a beautiful harbor at each end which nature has given. It is the same length as the canal through the Isthmus of Suez, namely 160 kilometres, or 100 English miles; but there is this difference, that half of it is already made by nature. When I said ten years I took a little margin. I have so great an esteem for the capacity of the "younger English" in getting through with things when they take them in hand, that I have a notion that they will fetch over such a big cargo of Chinamen that the canal will be opened in five years. Railways are rapidly stretching across the continent of Europe. Russia is pushing on her railways east-

* Read before the Institution of Naval Architects.

ward towards the Isthmuz of Suez to the Black Sea, to the Caucasus, to the Caspian. From Austria this line will be opened in five years on to Constantinople ; it cannot stop there, but must go on across the Bosphorus and right down the centre of Asia Minor to Bagdad, and then along the coast to the Indus, where it will join our Indian railways. Our European railways will be prolonged until English, French, German, Turkish, and Indian railways are all united in one continuous bond of human intercourse. China later, probably, will have railways. Africa, even, and Australia will feed the trade of their harbors by railways. Who shall predict the effect of all this going of things to and fro? It is our business here merely to see what effect all these things will have upon us, on our brethren, on our duties, on our skill, on our country, on our commerce, on our manufactures, on our ships. What, in short, will be the ships of the future? The fleets of the future will plainly have to be constructed in conformity with this work of the future; the changed circumstances of commerce and navigation will help us to decide the duties and to define the construction of this our mercantile fleet. Then the nature and the duties of our mercantile fleet, when we have considered them, will help us to decide the construction and armament of that fleet of men-of-war which has its chief duty in protecting our merchant fleets and the commerce which feeds them. First, I will examine the nature of the merchant fleets of the future. Nothing in the progress of commerce is more striking than the effect of railways upon ships. Railways and ships help each other, and railways and ships harm each other ; railways tend to kill all the smaller and slower class of ship ; railways help to load ships expeditiously, they supply large cargoes punctually and quickly. They favor large ships, punctual quick ships. They deprive small ships of cargoes ; they do the trade of distribution inland without the help of coasting vessels. Ports are still served by ships, but inland railways serve the places that ports formerly served. Distributing is no longer done by coasters ; railways have killed coasting sailing ships ; they have not yet quite killed coasting steamers, nevertheless they are very formidable rivals. As railways are made and multiplied, they inevitably run a severe race against coasting steamers; they take away their passengers, and inland they take away their customers. This effect will go on increasing, and they will take away the cream of the local coasting trade all round Europe, so that what remains will not be worth having. The future commerce by ships, therefore, lies not in small ships and local trade, but in large ships and long voyages, in commerce between continents. Modern commerce flows more and more every day into large centres ; modern transactions become larger and larger ; what is wanted is to be done at once, punctually, in bulk out of hand ; quick delivery is absolutely indispensable, and, therefore, large steamships alone can do it. Hamburgh, Havre, Marseilles, Trieste, Liverpool, Glasgow, Boston, New York, Calcutta, Yokohama, San Francisco, Melbourne, Sydney, are the centres of modern commerce and modern shipping, and the fleets of the future have, as their great duty, to do the great work of carrying the products of different countries between these great centres, and we have to fit these ships for this particular kind of work. To do the work of this enlarged changed world after 1870, we want a new merchant steam fleet. Its size must be proportioned to the length or stages of its voyages. Its power must be proportioned to the special nature of its work, and its speed is a mere matter of finance. The round voyage of the world is to be as follows :—England to Suez, 3,000 miles ; England to Bombay, 6,000 miles ; England to Calcutta, 7,500 miles ; England to Hong Kong, 10,000 miles. Shall we turn back, that is, another 10,000 miles, or shall we go on? From Hong Kong to Yokohama is 1,500 miles ; Hong Kong to San Francisco 6,000 miles ; Hong Kong to the Isthmus of Darien, 8,500 miles ; from Hong Kong home, 12,500 miles. Thus a voyage of 22,500 nautical miles is the round voyage of the future. Now, I venture to say that the smallest merchant ship for this work is a ship of 3,000 tons nominal. According to the structure of this vessel we can make her with a displacement of 5,000 or 6,000 tons, and we can give her an easy bulk for merchandise of 6,000 tons. I think she could be driven 10 knots an hour with 300-horse power. I give this as our smallest Oriental trader. Let me

next inform you that such a vessel can comfortably go through the canal of Suez on a low draught of water. I have talked the matter over with M. Lesseps, and he assures me that the vessel I am speaking of will easily and comfortably, as long as he lives, cut through the canal. He also assures me that he has no anxiety whatever as to the canal gradually filling up. Foreseeing the difficulty, the slope was made extremely small; but they have taken the precaution of keeping no fewer than 12 of their magnificent dredging machines in stock in case of any such difficulty arising. Now, with regard to the engines and the fuel of these ships, I think that 300-horse power of our modern engines would propel a vessel such as I have mentioned, without over-working, 10 knots an hour ; but I would suggest a great reserve power. We now, I think, make our engines and boilers too small ; we work them to the extent of their power, and we cannot make head against a contrary wind, in which case a steamship is in more danger than a sailing vessel. If you take a larger engine and a larger boiler than you want you will require a little more outlay at first, but you will get a more economical mode of working, and you have the advantage of a great reserve behind. Then with very good engines and boilers, according to our modern plans, the vessel will consume a ton of coal an hour—that is, a ton for 10 knots. A voyage of 6,000 miles would require 500 tons of coal. The engines and boiler cannot weigh less than 300 tons. The voyage of 7,500 will require 750 tons ; and the voyage of 10,000 miles 1,000 tons. Let me here mention that at Yokohama we are in the coal region, and in the course of the next 10 years you will be able to coal all your ships there ; that will be our half-way house. For the 1,500 miles trip 150 tons of coal will be required ; for the trip to San Francisco, 6,000 miles, 600 tons ; to the Isthmus of Darien, 8,500 miles, 850 tons ; and for the trip home, 12,500 miles, 1,250 tons. In the voyage to Bombay and home the ship will carry 1,500 tons dead weight of engines and coals, and have room for 2,400 tons of cargo. For Calcutta and home she will carry 2,900 tons dead weight, and have room for 2,100 tons of cargo. For Hong Kong, 3,400 tons dead weight, and only 1,600 tons cargo. But she will have this advantage—that on the home voyage, for the 6,000 miles voyage, she will have only 900 tons dead weight, and will have room for 3,000 tons of cargo ; for the 7,000 miles home voyage, 1,000 tons dead weight, and room for 2,850 tons cargo ; and for the 10,000 miles, 2,400 tons dead weight, and room for 2,600 tons cargo. Calculating the expense, etc., of the ship, I arrive at the following conclusions :—1. That this is the minimum ship and the minimum power ; 2. That she can go and return comfortably through the canal of Suez ; 3. that she can bring home and take out cargoes at existing freights, and leave a very good margin. Next we have to consider what sort of ship is wanted for a ship of war, to protect this class of merchant ships. It is perfectly plain that our future ship of war must go through the canal of Suez, and she must, therefore, draw not more than 25 ft. of water. The canal will admit, as a matter of possibility, vessels of that draught, but not as a matter of convenience, and I do not think that one ship of war should draw more than 22 ft. In the next place, I think you will agree with me that the ships of war that are to attend and protect our merchant fleet must be of a larger size, and they must be very much larger for two reasons. They must carry coal for a long voyage, and to be of any value they must go with great speed. They must carry coal for a longer voyage than the ships they accompany, and they must go much faster. The next point in the construction of our new fleet of war ships is this : are they to be built for the purpose of guarding our merchant fleet, or for the purpose of attacking land batteries? The ships that we have now constructed are perfectly capable of attacking land batteries. Iron-plated ships are absolutely necessary for that purpose, and those of the present construction amply suffice. But to accompany and protect the new fleet of the future we must have quite another class of steamships. First, it must be a ship from 5,000 to 7,000 tons nominal ; secondly, it must go certainly 15 knots an hour ; thirdly, it must be much more manageable and quick in its movements than even the most manageable and quick of those that we have now got. I have taken the opportunity of conversing with all the admirals who are

most likely and able to command the fleets to attack us, and I have gone with them thoroughly into this question. I have also had the privilege of conversing with the most distinguished officers who are likely to command our fleets. I will give you the conclusion, which many of them will refuse to admit in public, but which I think it is the interest of the British nation thoroughly to know and deeply to weigh. It is agreed by the most able sailors I know that the one weapon to fight with is stem on. Though he will deny it, and say he will not do it, the one intention of every man who is likely to command a fleet is to give the enemy his stem on, and run him down at all risks. May I say that the weapons constructed for this fence are not the weapons best suited for this practical purpose? I, therefore, earnestly call upon all naval constructors here present to give their minds with the most untiring devotion to the one fence of running down. You will see that other nations have thought of that, and made their preparations for it to a far greater extent than we are doing, or possibly have any notion of doing. Now that leads us to the next question—what guns shall these ships have? and what protection shall the ships have? I think it is not necessary that they should have protected batteries of guns. It is indispensable that the engines, the boilers, the magazines, and all the essential elements of the ship, should be thoroughly protected; but I do not think that the gun-deck of such ships requires any but a small protection, because with this new fence the battle of the sea is over in a very few minutes. Consider what a naval engagement must be between two such ships. I see my enemy coming towards me; I either run away, or I do not, or I go forward; if I run away the less that is said about that the better; if I lie still there will be nothing to say, therefore I go to meet my enemy. When we meet, what is the great point between us? Which shall give the other the stem. It is not a question of how many shots I shall fire out of a round turret. When we get close to one another one of us succeeds in running into the other; if not, we both sheer off, and then is the time, and only for a moment, when the guns are wanted—not one, or two, or three guns, fired at a long range, but a broadside of the greatest number of guns you can have ready loaded to discharge as you turn. What you want is a broadside of the largest guns you can place on board the ship, thoroughly unprotected, with competent gunners, who, I may say, do not care two straws for the protection you are offering them. That broadside must be discharged in a moment, and the larger mass of shot you can, at that critical instant, pour into your enemy, the better. Then you go away, turn round, and come back again. That is the mode in which a battle must now be fought out. Am I wrong in saying that such a battle requires a totally different weapon from any that we have hitherto had?

THE BOUTET BALANÇOIRE.

From "Engineering."

We notice that Charles Boutet has, not a little to the discredit of the Patent Office, obtained protection for his bridge; there really ought to be exercised sufficient supervision to prevent such so-called inventions from being sanctioned, as they are, to a certain extent, by the stamp of the Great Seal. Thus, notorious Pidding knows well that whenever he obtains provisional protection for some nonsense, he can always find a certain number, who are to be led into the belief that a patent is equivalent to a "Royal Charter"—words of vague but portentous meaning to the ignorant. Whether Mr. Boutet seeks further to establish himself by the help of his patent, we know not; possibly a pressure has been brought to bear upon him similar to that recently developed in the case of the Fenian leaders, whose followers insisted upon smelling powder or getting their money returned. This is, however, beside the question. Mr. Boutet is laboring hard at the cause he has taken up, and the publication of his patent and its accompanying drawings gives us an insight, we presume, into his latest designs. That these are thoroughly in keeping with all that

the patentee has hitherto done is to be expected, and we take it for granted that the drawings illustrate the method on which the 100-metre model of which more or less has been said, and that is a fac-simile of the great 3,280-ft. channel spans, has been constructed. There are six distinct features in the patent : the cable lattice, the piers and mode of sinking them, the means of straightening the cables, the means for twisting the cables, and the hand-rail upon which the stability of the bridge depends. In addition, there is shown and described an arrangement for deep-sea levelling—a plan for ground and bottom fishing Mr. Boutet should submit to the consideration of submarine telegraph engineers.

Mr. Boutet shows a drawing of a bridge of which the abutments are 108 ft. high, and the span some 180 ft., although, as this latter is broken in the centre, and as length of span is a matter of no moment, we may presume it represents a bay, say, 3,280 ft. long. Upon each of these abutments is placed a bed-plate with bearings for the cables to lie in, and an adjusting arrangement consisting of a slide resting in a cast-iron frame, and carrying, by means of brackets, a bar, upon which the ends of the cables are looped. A series of screws are added by which the slides can be set up, and the cable straightened. The cables are shown about 9 in. in diameter, and are stretched from abutment to abutment, parallel to each other, and about 2 ft. apart in a horizontal row, smaller cables being introduced transversely at certain intervals to bind the others together. This web is then sandwiched between two rows of planking, the upper one being made of oak, the lower one of deal, and the network is thus "held firmly between the two plank surfaces or floors." Transverse beams (they are called longitudinal in the specification) are placed at regular distances, and to them are fixed the hand railings, which not only "serve as railings to fence or protect the passengers, but also add to the vertical rigidity of the structure." N. B.—The patent drawings show this hand-rail some 23 ft. in height. In long spans the inventor reduces the area of his cables by making them in short lengths, and linking them to transverse bars, the number and size of the cables decreasing towards the centre from the abutments. In order to straighten the cables—for it must not be forgotten that Mr. Boutet maintains that he does make them quite horizontal and even cambered—a primitive device of a train of levers is patented, and a common arrangement for twisting the wires is also shown.

This wonderful bridge consists, then, of a platform made of a number of ropes stretched horizontally (which is impossible), and laid parallel to each other woven with cross cables, and held at the abutments as described. It is, in fact, nothing but the old rope bridge used in the East any time these last 3,000 years, secured between two points—and stretched to breaking. In all justice, however, to Mr. Boutet, it must not be forgotten that we are describing only the invention as noticed in the specification ; he *may* have, of course, something entirely different, and which deserves the eulogies bestowed upon it. But we have only to do with the matter before us, and are bound in the meantime to conclude that the invention is fully and completely set forth in the patent. According to the description, Mr. Boutet evidently relies upon his timbering and hand-rail for the stiffness of his structure, and this could, of course, be effected in the small models ; while in the 100 metre span they would be equally utilized. But it is scarcely necessary to point out the utter absurdity of such an arrangement in the extravagant spans Boutet speaks of.

The introduction of the cables is, indeed, worse than useless, and the less we hear about them the better. And here we must again call attention to the fact that only recently a journal of high standing and influence has drawn public attention to the Boutet bridge as a marvel of strength and engineering skill ; a panegyric the "Scientific Review" has endorsed by reproduction. In that notice Mr. Page's remarks, delivered in the course of a paper read not long ago at the Society of Arts, have been wofully misunderstood. When will periodicals, whose duty it is to guide, cease to impede the real cause of progress by injudicious advocacy ?

A new cylindical iron railway carriage has been patented by Mr. N. Maccartney, of Glasgow.

THE STRENGTH OF BOILER PLATES.

From "The Engineer."

We are not about to speak of any of the fantastical theories once advanced to explain boiler explosions ; we shall deal with a single question, believing that our readers will find quite sufficient food for thought in its consideration to last them for some time to come. This question is, do boiler plates become brittle in use, or do they not? In other words, does a plate in a boiler gradually deteriorate in quality, or does it not? Whether a rail deteriorates or not, is a question which has been hotly disputed, but, until very recently, no one thought of assuming that a boiler plate, externally sound and free from corrosion or marks of overheating, could be otherwise than as good as when it was worked up by the plater. It just begins to dawn on the members of our profession that it is possible that a plate may undergo molecular change of some kind during twenty years or so of work, and this once proved, a most important addition will have been made to our knowledge. We have no doubt whatever that boiler plates do, under certain circumstances, undergo a rapid degradation of character, resulting in absolute untrustworthiness or ultimate failure. It is not difficult to adduce evidence in favor of this belief, or a theory to explain it ; we shall give both ; not that either fact or theory is in any sense conclusive, but because both are suggestive, and may—we trust will—lead to further inquiry—the foundation of all knowledge.

In a recent impression* we described the results of certain experiments conducted by Mr. Carmichael, to determine the strength of boiler plates many years in use. We, at the time, made a request, which we now repeat, namely, that whenever an old boiler is broken up steps shall be taken previously to test its absolute strength ; and the results placed on record in our pages or otherwise made public. One gentleman of large experience has courteously responded to our invitation, and sent us particulars of some tests of certain boiler plates which had been fractured in an explosion, it is unnecessary to say where. The strips were cut out where they could be got. Nos. 1 and 2 were old plates ; No. 3 had been a repair plate :—

No.	Area of section.	Broke with tons.	Breaking strain per sq. in. area.	Stretch.	Contraction at fractured part.
1	.4556	9 5-20	20 6-20	5 per cent.	6 per cent.
2	.4690	8 5-20	17 11-20	4 "	4 "
3	.4824	10 5-20	21 4-20	5 "	5 "

The boiler was one of the egg-ended cylindrical type, plated longitudinally, and had been in use about fourteen years. The pieces Nos. 1 and 2 were hard, and fractured soon after they left the line of the plate ; No. 3 stood a fair test. "These," writes our informant, "are deserving of attention, as showing that a brittle or hard plate may give a good result to a direct strain."

The next results are from a rent plate from the boiler at Bingley, which exploded in June last; the strips were each way of the grain, and gave exactly the same results:

No.	Area of section.	Broke with tons.	Breaking strain per sq. in. area.	Stretch.	Contraction at fractured part.
4	.5289	11 10-20	21 14-20	3 per cent.	5 per cent.
5	.5289	11 10-20	21 14-20	3 "	5 "

These were subjected to other tests, as follows :—A, strip hot, bent inside of the plate outside, the ends were brought together, and there was found to be a small crack across the bend ; B, a strip hot, outside of plate, outside of bend—wide frac-

* "The Engineer" for April 22d.

ture ; C, strip cold, broken from inside ; D, strip cold, broken from outside ; E, F, G, broken across the grain, with the grain and diagonally—broken cold. The results of C, D, E, F, G, were similar, showing that the outside of the plate was deteriorated and crystallized, but that the inside was fibrous and of fair quality ; H, strip of plate, set cold from the outside—a slight crack was found at the angle of 4 deg. ; J, strip set cold from the inside to the angle of 13 deg., at which a slight crack was found. The letters refer to the labels on the specimens. This plate was taken from the shell, and was said to be an original plate, having been in the boiler for twelve years.

Now, it is to the last degree unlikely that any boiler maker, with the least regard for his reputation, would use a plate so brittle that it stretched but 3 per cent., when we bear in mind that a good boiler plate will stretch from 7 per cent. to 14 per cent., and even more. It is a legitimate deduction, we think, from the foregoing figures, that the plates deteriorated in quality during service. It remains to be seen how such deterioration was brought about ; and this leads straight up to a theory—or, more strictly speaking, the sketch of a theory—which we have already referred to.

Many able engineers hold that no deterioration whatever—always excepting corrosion—can take place in a bar or plate of iron, unless it is taxed above its limit of elasticity. Whether this is or is not true of plates, bars, or rails, at normal temperatures, we shall not stop to inquire. It is not true, in our opinion, of boiler plates, or of any other forms of iron exposed to considerable degrees of heat. M. Tresca has shown very conclusively that iron will "flow," even in the apparently solid state, in a way precisely similar to ice in a glacier, or the lead "squirted" into bullet bars under hydraulic pressure ; all that is necessary is time and power. It may be safely assumed that there is no substance in nature which can not be made to "flow." In other words, that an absolutely rigid solid, a something the molecules of which do not and cannot change their position with regard to themselves and extraneous objects, has no existence save in theory. It is also certain that heat operates powerfully in promoting the flow of solids. Who will maintain, then, that the molecules making up the plates of a boiler, said plates being exposed to a temperature on one side of perhaps 200 deg., while the other is in contact with water at, say, 220 deg. or 280 deg., will not change places and assume new relations towards each other under the influence of heat, strain, and motion combined ? We say motion, for it must be borne in mind that every boiler is continually changing its shape from hour to hour, or even minute to minute, as the pressure and temperature vary. To fancy that these influences—heat, strain, and motion—can continue to operate for years without bringing about some change in the structure of a boiler plate, is to assume that the molecules possess a degree of immobility which they do not possess. If we apply a heavy strain to a piece of plate we can upset all relations previously existing between its component particles ; the plate contracts and becomes hard. Have we the least ground for assuming that under a less strain no change will take place ? Experiment clearly proves the contrary, and we need not dispute the point. In the very experiments we have recorded it appears that the outside of a plate exposed to a high temperature becomes crystalline, while the inside remains fibrous and sound.

Our theory is, then, that all boiler plates undergo a change in quality by the lapse of time, and under the influence of heat, strain and motion ; that such a change leads up to explosions ; and that the engineering community knows nothing with certainty about this deterioration, and this is the higher ignorance of which we have spoken. It is simply a coincidence, an accident of nature, which we cannot explain, that this change should result in tough iron becoming brittle and untrustworthy, instead of sound and tough. We by no means pretend that this deterioration is the invariable cause of boiler explosions ; but it no doubt conduces to their occurrence, and certainly increases the destruction of life and property. A tough boiler will open and leak, when a brittle boiler will fly to atoms ; and in this brittleness, no doubt, is to be found the primary and efficient cause of the ruin which attends the failure of an old boiler. It remains to those interested to investigate this theory, and endeavor, by practical tests, to ascertain whether there is or is not some law or laws in obedience

to which the work of deterioration proceeds; whether, and to what extent, if any, different makes of iron suffer more or less deterioration; and how many years of fair service should be regarded as enough to secure the superannuation of a boiler, even though it may appear to be perfectly sound.

DESCRIPTION OF THE ROCK-SALT MINES AND SALT MANUFACTURE IN CHESHIRE.

From "The Mining Journal."

Rock-salt is said to have been first discovered in Cheshire in the year 1670, in boring for coal; but the manufacture of salt from brine springs appears to have been carried on some centuries previous to this. The Trias and Permian formations have been described as follows—under the Lias—in Cheshire and Lancashire:

1.—Keuper marls of Cheshire.
2.—Upper New Red Sandstone, or bunter.
3.—Permian—red and blue marls, with limestone.
4.—Permian—Lower New Red Sandstone.
5.—Coal measures.

The rock-salt in Cheshire occurs in the Keuper marls; these are stated to be 200 yards in depth, but the total depth is probably much more than this. There are seven salt mines at present in operation in the neighborhood of Northwich, named in the order of quantity of rock-salt raised, as follows:

Name.	Proprietors.
1.—Marston Hall	Mr. W. Hayes.
2.—Platts Hill	Mr. Thompson.
3.— "	Mr. W. Stubbs.
4.— "	Mr. Judson.
5.— "	Mr. Williamson.
6.—Old Marston	Messrs. Fletcher and Rigby.
7.— "	Messrs. Thompson and Jackson.

Besides these there are 7 or 8 other salt mines suspended. The area of rock-salt that has been proved in this district is considered to be about 4 sq. miles. It does not vary much in depth, being generally found at 108 yards, from the surface to the bottom of the rock-salt.

The Marston Hall Mine produces upwards of 40,000 tons of rock-salt yearly; this is about one-half the total quantity worked near Northwich. The mine is leased from Lord de Tabley. The lease of mineral was originally within a radius of 7 chains from the pit, and 15 acres in area; this has been increased, the area now amounting to 50 Cheshire acres. The mine has been in operation 20 years. There are two pits at Marston Hall, about 12 yards apart, sunk through the salt beds; the depth is 105 yards to the floor of the bed that is worked. This bed is 14 ft. thick, of nearly pure salt.

STRATA PASSED THROUGH IN THE PITS AT MARSTON HALL.

				yd.	ft.	in.
1.—Brown clay				3	2	0
2.—Brown soft marl				3	2	0
3.—Brown friable earth, beds of blue marl, and gypsum				38	0	0
4.—Inferior rock-salt, not worked	30 yd.	0 ft.	0 in.			
5.—Brown metal, or marl stone	5	0	0			
6.—Blue metal, or marl stone	5	0	0			
7.—Inferior rock-salt, not worked	15	0	0			
8.—Bed of clean rock-salt worked	4	2	0 =	59	2	0
9.—Inferior rock-salt	2	2	0			
10.—Hard brown clay						
Total				105	0	0

The earth at No. 3 is not a marl; vegetation will not grow in it—where found, it is an indication of the existence of rock-salt below. Beds Nos. 4, 7, and 9, are not worked; the rock-salt is intermixed with blue and brown marl. The rock-salt working is generally confined to No. 8 bed. The bed of clay, No. 10, has been sunk into 60 yards in the locality, but not through it, so that the extent of the saliferous beds cannot be said to be fully ascertained until the upper New Red Sandstone is reached.

The shafts for the first 40 yards are secured with timber, and are made 4 ft. sq.; below that, 30 yards of cast-iron cylinders are inserted; these are of 3½ ft. internal diameter; they were placed after the shafts had been completely sunk; each cylinder is 9 ft. high, the full circle of the shaft; they are bolted and wedged at the joints, and filled behind with cement. By this means the springs usually found at the top of the rock-salt are completely excluded, and the mine is perfectly dry.

On descending into the mine the extent and height of the excavation, and the remarkable strength of the rock-salt roof, are the most striking points to a stranger. The bed worked—No. 8 in the section—is generally 14 ft. thick, it is got in two divisions, the top part, $5\frac{1}{2}$ ft. thick, is first got; then the lower part, $8\frac{1}{2}$ ft., is got a few yards behind; these are worked in a continuous face, with pillars intervening at proper distances. Pillars are left 10 yards by 8, with spaces of 30 yards between them, each way. About $\frac{1}{19}$ of the whole is thus left in pillars; as the working faces extend further from the shafts a larger proportion is left in pillars. Powder is used largely for blasting, about 1 cwt. is consumed daily. The roads at the working face are laid 10 to 12 yards apart, 3 ft. gauge; the same buckets are used on these roads as in the shafts; they are placed on a wooden frame; the frame is fastened below the axles; flanged wheels run on iron bars as rails; sixty persons are employed underground, from 7 A. M. until 4 or 5 P. M. About 20 acres of the 14-ft. bed have been extracted. No timber or other support than the pillars is required. The bed has a slight fall to the east. About 3 ft. of the floor and the same thickness of the roof is being got in 2 or 3 places, but the rock-salt is intermixed so much with marl as to be not worth working for general purposes at the present day. The mine is quite dry; great care is taken to exclude water from the works, otherwise it might be better to let them fill up with water, and pump brine from them for the manufacture of white salt. The rock-salt, as worked, contains by analysis 97 per cent. of chloride of sodium (common salt) and 3 per cent. of other ingredients. Its color varies from nearly white to dark brown. Natural ventilation is depended on in winter; in summer some artificial means is needed to clear the mine of smoke.

The winding-engine at Marston Hall is a 21-in. beam-engine, $4\frac{1}{2}$-ft. stroke, two flat-rope drums, 5 ft. in diameter on second motion. Two Lancashire boilers, 25 lbs. steam pressure. One rope works to each shaft in front of the engine. Hemp ropes only are used, and one will wear two years; wire-rope would not be at all durable here, owing to the well-known action of salt and water on iron. The same engine pumps surface water occasionally, and drives a circular saw. Recently ingenious machinery has been erected for grinding rock-salt; this is effected by a 16-in. horizontal engine, 3 ft. stroke. The rock-salt is first broken by one of Blake's crushers, from this the material is carried horizontally some distance by an Archimedean screw; it is then raised by a bucket elevator, from whence it descends to the grinding rolls. From the rolls the crushed rock is taken horizontally by a screw to the foot of another elevator, by which it is raised to the vibrating riddle; the rock-salt by this is separated into two sorts, rough and fine. The rough is used in the manufacture of copper and in alkali works; the fine, resembling sand, is used for agricultural purposes. A large proportion of rock-salt is sent away in lumps, a better price being obtained for large selected pieces. This is exported extensively to Holland and Belgium, and there manufactured. No white salt is admitted into these countries.

At a short distance from the drawing shafts a shaft is sunk to the rock-salt to the depth of 40 yards. A small engine is erected to pump brine from it by a connecting rod and T-bob and 6-in pump; the pump is close-topped, and by that means the brine is elevated a sufficient height to run to a large cistern, from whence the brine is run to the evaporating pans as required. There are three pans in operation, 60 by 30 ft. each, for the manufacture of white salt; each pan is heated by four fires. The Marston Hall Works are situated near to the Trent and Mersey or Grand Trunk Canal. There is a branch railway of $1\frac{1}{2}$ miles to join the Cheshire Midland Railway at Northwich.

Another branch of the works, also belonging to Mr. Hayes, is at Anderton, one mile distant from the mine. There are 16 evaporating pans here, 60 ft. by 30 ft. The works are devoted solely to the manufacture of white salt, from the saline springs, pumped from two shafts in the immediate neighborhood. The Anderton brine is understood to be fully saturated; it contains 10 times as much salt as sea-water. One gallon of brine yields about 42 oz. of common salt. The analysis of this salt gives 92 per cent. of chloride of sodium and 8 per cent. of water. The production of white salt is about 30,000 tons per year. Other two companies—the British Salt Company and Darcey and Gibson

—have works adjoining to Mr. Hayes, the produce from each of which is about the same as that named. For making stoved or fine butter salt, the brine is heated to the boiling point; this is 226 deg. For common rough salt about 160 deg. of heat is applied. For large-grained crystalline salt, for fisheries, the brine is heated from 100 to 110 deg; no agitation is then produced, and the salt forms naturally in large cubical crystals. There are two shafts about 20 yards apart, sunk to the brine springs near the works above referred to; they are 75 yards in depth, to the top of the rock-salt. A pumping engine is erected at the top of each shaft. Each is a 24-in. beam engine, on second motion. From the second shaft motion is communicated by means of two cranks and connecting rods to two beams fixed on the front wall of the house; to the outer ends of these beams the pump rods are attached. There are two pumps to each engine, being $8\frac{1}{2}$ in. close-topped bucket lifts. The four pumps supply three reservoirs, one appropriated to each work, from whence the brine runs to the evaporating pans. The brine springs are always found at the top of the rock-salt; the pumping operations occasion a great subsidence of the ground, over a much larger area than has been ascribed to the deposit of rock-salt. With every addition of fresh water derived from the surface more salt is dissolved, and thus a continual extraction and undermining is going on, consequent on the pumping. Nearly every house in Northwich may be said to be damaged by undermining, though there is no brine pumped in the immediate locality.

The produce of the Anderton Works is sent away, either by the Trent and Mersey Canal or by the River Weaver, which is navigable to Winsford, 7 miles from Anderton. There are five other works near Anderton where salt is made from the saline springs raised in their neighborhood, besides eight near Marston, and seven near Northwich, and several at Winsford also manufacture salt from the springs. Notwithstanding the constant demand for this prime necessary of life, and the fresh uses to which it is applied, as in the manufacture of copper, and for agricultural and other purposes, the trade is not in a flourishing state; the production more than keeps pace with the demand, and the produce from other districts has come into competition in the markets where Cheshire salt has been exclusively used. Rock-salt is now sent from Belfast by sea to supply the Newcastle and Glasgow chemical works; this has, to some extent, reduced the working of the Northwich mines.

Salt is manufactured from brine in the neighborhood of Droitwich, in Worcestershire; this has for a long period supplied a certain district with salt. Staffordshire also produced salt some years ago, from brine springs, but the manufacture, we understand, has ceased.

DRINKING FOUNTAINS AND PURE SPRING WATER.

From "The Builder."

It is a curious thing to note how the great powers that be sometimes go about things. There are two important questions at this moment before the British Parliament, of most momentous import to the whole British public: one is, that the said public shall be from henceforth compulsorily educated; and the other is, that intoxicating liquors generally should either cease to be drunk altogether, or, at least, the sale of them confined to very fashionable localities; and, to help to wean the poor helpless public from the temptations of alcoholic liquors, a society some time since sprang into existence, and a series of fountains, as they are termed, have been put up by it in all the poorer districts of London, for the purpose of supplying people with what the Drinking Fountain Society call "pure and wholesome water." Now, it is a curious fact, that all the fountains are carefully boarded up and the water-supply from them made to cease during the whole of the *winter* months and cold weather; indeed, just at the time when the sale of spirituous liquors is at its maximum, "to keep the cold out." Why is this? Surely the public, the lower orders, must drink in the cold weather as well as in the hot; and the temptations to go astray are quite as

great, if not greater, in the cold of winter as in the heat of summer. But so it is, and undoubtedly it is all right and proper; but as the season has just commenced when all these boarded-up fountains are uncovered, and the water from them allowed to flow again (at least by day, for we have found them shut up through the night, even in summer), it seems worth while to say a few words about these drinking-fountains, on the fountains themselves *architecturally*, and on the sort and amount of water which they supply. For this purpose we would call attention to the recent elaborate and instructive Report, with an appendix, on the subject of the London water supply; it would seem to call for some notice beyond what it is likely to meet with at the hands of those who look on it only as a sanitary matter. We are what is called a practical people, so that in the event of any change for the better taking place, either in the kind of water supplied to Londoners, or in the mode of its supply, we may be quite sure that *art* will come in but for very meagre notice, if for any at all. A few words, therefore, may not come amiss about it before anything is finally determined on. To begin at the beginning. *Rain*, says the "Report," is the source from which all water-supply is obtained, and there are *three* modes by which the water thus provided by nature is made available for the supply of towns. We ask attention to them. The *first* is to bore down into the porous strata, and thus to come directly to the purest of all water, that which springs up into wells, and which sometimes reaches the surface and bubbles up as springs. *Secondly*, that which is obtained from rivers, and which is the natural drainage of a country. The Thames thus drains not less than 6,000 square miles of land, *i.e.*, the rainfall over this area falls into the river-bed. The *third* mode is by forming large reservoirs in hilly districts, and then to collect and store up in them the rain or surface water, this being conveyed by pipes to where it is wanted. Be it observed, that none of these methods insures the collection of *pure* rain-water, the water being necessarily mixed with earthy and mineral matter by the fact of its passing through or over the ground on which it falls. It seems, therefore, a pity, as we have before urged, that some plan has not been devised for collecting pure rain-water from the tops of houses into tanks or cisterns. This would be a fourth mode of water-collecting. Rain, it is said, is the very purest and softest of all waters, it being the result originally of simple evaporation. If a glassful of Thames water be simply allowed to settle so as to become clear by the mud falling to the bottom of the glass, this water on being tasted will be found to be *soft* and almost like June rain-water. Or, should any one be bold enough and hardy enough to *bathe* in the river, he will find the water delightfully soft and *pure*—pure barring the mud. If, then, after these two simple but bold experiments, the same person will dive into a common plunge-bath, and venture to taste the water from one of the common drinking "fountains," as they are so poetically called, he will discover that though the water be said to come from the same source—the Thames, the bath water will feel like pounded ice, and as hard; and the taste from the "fountain" like unto some diabolical semi-warm mixture of he knows not what; as hard as cast-iron and about as palatable! What, therefore, we would ask, do the water companies do with the water? Why not leave it alone, and allow the pure river water, after depositing its mud to find its way into baths and fountains in its *natural* state?

But, it may be asked, why take the "river" water, with all its impurities, about which there is so much in this Report, all the great scientific authorities contradicting each other about it, no two of them seeming to agree? Now, it so happens, says the Report, that no less than two-thirds of the Thames basin consist of porous and permeable strata, such as chalk, oolitic limestone, and sand and sandstones of various kinds, all of which receive and absorb a large proportion of the rainfall, and store it up in vast subterranean reservoirs, forming well and spring water, water made pure and palatable by great natural processes, costing nothing but the getting at it, by the sinking of wells and pump-pipes. This grand natural process reduces organic matters to a minimum, and mineral matters to the smallest amount; is independent of the seasons; gives uniform temperature, and the filtering process as perfect as can be; for, as the "sections" show, from 50 ft. to

300 ft. thick of sand, or limestone, or chalk, are gone through. It is something wonderful what an amount of evil is put up with by the poor British public. There is all this exhaustless supply of the purest and best of water under our very feet, and needing only the most common of mechanical appliances to come at; yet it is never even thought about, while the substance called water in common use is really unfit for any purpose whatever, either for washing or drinking.

But there is another aspect of this important subject which will, if not at present, at some future day meet with the attention which it is worth. If we travel into countries and towns uncivilized and *barbarous* enough, such as Constantinople, or Damascus, or even Utah, on the Salt Lake, it will be found that not only is there a plentiful—nay, magnificently liberal supply of the purest and most delicious of water—but no pains and expense have been spared to render this supply not only complete, but pleasant to the eyesight. The reader will see nothing of this in the Report. London and Constantinople or Damascus are wide enough apart; but in the last-named cities *the water is alike utilized and made beautiful.* Instead of the little dribbling, sickly streams which flow from our drinking fountains, and which take their time to fill a wineglass, and which in most cases spout out of a foot or two of paving-stone into a shallow basin, the size of a common dinner-plate, the real fountains to be found in those far-off and barbarous cities are really works of art, to be seen a mile off, with water enough to be at least seen and heard as it falls; a something to pause to look at, and a happiness to see. A photograph of a beautiful fountain worthy of the name, near the "Sweet Waters" of Asia, and quite a gem of Moslem architecture, may be seen in Gautier's Constantinople, together with another—but far too big and luxurious for our shopkeeping nations—that of the fountain of the Sultan Selim. Constantinople, be it observed, is a barbarous and almost heathen place, and a remnant of old and fast-failing times and ways of work, and unhappily modern improvement will consist, when it thoroughly seizes hold of this place, in doing away with all these quaint "water supplies," and substituting "taps" everywhere. Let the intelligent artist reader balance the loss and gain mentally and bodily. London improvements would seem now to consist mainly in pulling down as many houses as possible, and forming large, awkward, open waste spaces; would it not, we would ask, be a good plan to occupy some of these with drinking fountains worthy, at least, of the name, with the water supplied from the lower strata, as explained in the Report,—*i. e.*, with well or spring water, of which there is such an inexhaustible supply. Such water is always pure, drinkable, and of even temperature, and constant in quantity. In these fountains the *water* for which they are constructed should show itself visibly—*i. e.*, it should be seen that the fountain was made for the water, and not the water for the fountain;—large open basins and a perpetually running stream. It would be difficult to devise a plan more likely to be acceptable to the public, especially the poorer and out-door public. It would be easy to name some score of open spaces where "fountains" such as we have indicated would be useful and desirable. Nothing can be worse than the now so fashionable mode of improving London. Everything is destroyed, and there is nothing in idea to replace the old plan of streets, bad as they are thought to have been, or are. We may, before it is too late, learn something from Constantinople and other of those distant and really wonderful places, truly called cities, built and planned so long before science and "art principles" had any existence, but yet at a time and by a race of men whose ways we may well try to recall and humbly imitate and follow. There is, surely, a long distance between a Turk and an Englishman; and if the Sultan and his subjects are to be civilized by the adoption of English ways, let us borrow something from them before it is lost for ever.

One other thing there is in this water-supply question which ought not to pass without notice, as it is not a little curious, and shows the universality of the great laws of nature. Everybody has heard of the impurity of London river-water, one way or another; but the Report says, that taking properly-filtered samples of Thames water, we shall see an "extraordinary regularity in the albuminoid character of good

town waters during summer months." Thus it would appear, that Thames water, Manchester water, Edinburgh water, and Glasgow water from Loch Katrine, show in a most remarkable way the great constancy in the amount of such impurities as *ammonia.* Thames water gets even sewage. Manchester water comes off the moorlands of Derbyshire, so it is pure; Edinburgh, from springs some miles from the city itself, yet is the percentage of ammonia nearly uniform. It is certain, therefore, that there are great natural processes at work, always tending to equalize the quality of all natural water that is freely exposed to air and light.

THE "VICTORIA" STONE.

[From "Engineering."]

It has always been the aim of practical workers in the fields of science, to effect a combination of material which should give a substance capable of taking the place of natural stone in the constructive arts. One of the most striking and beautiful results is witnessed in the concrete stone with which the public are now generally familiar. In a lesser degree we see the same effects produced in terra-cotta and in various forms of brick and pottery ware. In all these, however, heat is required either to effect the disintegration or combination of the elements composing the material. But an entirely new process has recently been perfected by the Rev. H. Highton for effecting the same object in which the aid of heat is entirely dispensed with. The process of manufacture is as simple as it is efficient, and consists in mixing broken granite with hydraulic cement and steeping the whole when set in a solution of silica. This manufacture is now being carried out by the Victoria Stone Company, at whose works in the Bonner road, Victoria park, we recently witnessed the process in operation. Two kinds of granite are used, Mount Sorrel and Guernsey, the former being of a brown, and the latter of a blue, color. This granite is the refuse of the quarries and is broken up into small fragments on the works. It is then mixed with Portland cement in the proportions of four of granite to one of cement, sufficient water being added to render it of a pasty consistency. In this state it is filled into the moulding frames, and is allowed to stand thus for about four days in order to dry and consolidate. After this the slab or other object is taken from the mould and placed in a solution of silicate of soda, where it remains for about two days more, when it is ready for the market.

It is in the preparation of the silicate solution that the chief merit of the invention, in a chemical point of view, lies. We need scarcely remind our readers that Portland cement, or any other concrete into the composition of which lime enters, is capable of being rendered extremely hard by immersion in the above solution. But the great cost of the silicate of soda has hitherto prevented the practical application of this fact to the commercial production of artificial stone. Besides the constant expense of renewal, there still remained the fact that the silicate of soda after losing its silica by absorption, became too caustic for workmen to handle conveniently. Working on this idea, however, Mr. Highton at length succeeded in practically solving the problem of a solution which combines economy in cost with facility in use and efficiency in results. This solution he produces in the following manner: The beds beneath the chalk formation at Farnham, Surrey, consists of a large deposit of a soft stone, containing about 25 per cent. of silica, which has this peculiarity, that it can be readily dissolved in a cold solution of caustic soda. The soda solution is placed in the tanks which are to receive the moulded concrete, and the material containing the silica is ground up and mixed with the bath. The lime removing the silica from the solution, liberates the caustic soda, which dissolves fresh silica from the Farnham stone. Hence the process is continuous, the soda acting as a constant carrier of the silica from the stone to the cement, and the bath may be kept up to the proper degree of strength, and thus the work of production may be carried on indefinitely. The cost of the silicate of soda having been once incurred, there is no further expense attending the pro-

cess of petrifying the concrete blocks than that of obtaining the Farnham stone and of using it. Mr. Highton deserves credit no less for having obtained flint in this shape, than for having applied it in this practical manner, which is as simple as it is ingenious.

The material produced by this process is known as the Victoria stone, or petrified concrete, and the principal objects which are moulded from it are flagging, sinks, mantel-pieces, coping, and cap stones, sills, stairs, and such like articles for which is is especially adapted. It is not so applicable for finer productions such as finely cut mouldings, etc., so that the company does not lay itself out for this class of work, although we brought away with us a small casting of this material, which comes out very sharp and clean. Its main value will rest in its adaptability for heavier goods, such as paving, building blocks, etc. In the former capacity it has had some fair testing in various parts of the metropolis under heavy foot passenger traffic. Some of the stone is laid in the Poultry, just in front of St. Mildred's Church, and some more on Blackfriars Bridge, the results hitherto proving most satisfactory. The Victoria stone laid is only 2 in. thick, as against York paving 3 and 4 in. thick. In the provinces, also, it has been long under trial, and is well spoken of. Being impervious to moisture, it soon dries after rain, whilst it is well able to resist frost.

With respect to the strength and durability of the Victoria stone it may be mentioned that it possesses these properties in a much greater degree a few months after manufacture than when newly made. This increase of strength is attributable to the gradual hardening by time, of the flint, which is at first thrown down in a condition resembling jelly. Thus it is found that a slab of the concrete 2 ft. wide and 2 in. thick resting loosely on supports 2 ft. apart, will bear in about 10 days' time an average weight of about 700 lbs. in the centre. After having been steeped in the silicate bath, however, it will sustain more than 1,000 lbs., whilst in five months it will carry 1,700 lbs., and in nine months as much as 2,400 lbs. Mr. Kirkaldy has tested the Victoria stone both for resistance to crushing and for transverse strength with the following results. A beam with a section of 4 in. $\times$ 4 in. made with a special view of transverse strength, resting loosely on supports 20 in. apart, sustained a weight of over 4,100 lbs. in the centre, equivalent to nearly 4 tons evenly distributed over the beam. The crushing strength of the Victoria stone was found by Mr. Kirkaldy to be 6,441 lbs. per sq in. A block of this stone presenting a surface of about 6 in. $\times$ 9 in., sustained a weight of nearly 160 tons. This resistance to crushing strain points it out as well suited for foundations for heavy superstructures. Its cohesion has been proved at a London Brewery where it has been laid to replace ordinary paving which was constantly been broken by the rough handling of barrels. Since the Victoria stone has been laid not one slab has been broken, although the previous flagging required constant renewal. In fine, the Victoria stone is cheap and simple in production, and appears well calculated to successfully compete with ordinary stone in the various applications to which we have alluded.

The sinking of the ground in Turnmill street, Clerkenwell, near the Metropolitan Railway, was caused, it has been discovered, by the falling in of the sewers, caused by the flooding of the old Fleet Ditch. The inhabitants of the houses in the neighborhood have been kept for weeks in a state of alarm, and a great number have left. The railway also has been under constant supervision. Now that the cause is discovered, steps have been taken to make all secure.

It has been found that the hyposulphite of soda, which is now manufactured very cheaply, for the use of photographers, is much better than the common washing soda to wash delicate objects. It attacks neither the skin of the hands nor the objects to be washed, as does the common soda; and at the same time it is an effective bleaching agent, and takes out many spots better than any other substance.

The preliminary works for the construction of the railway from Puerto Cabello to Fonseca Bay are being proceeded with, and the plant is being supplied by the contractor, Mr. Turner; the season being favorable and the country at peace.

THE VAL-DE-TRAVERS ASPHALT PAVING FOR STONES.

From "The Mechanics' Magazine."

On the 25th ult. Mr. Haywood, the engineer and surveyor to the City Commissioners of Sewers, made an official examination as to the results of an experiment in street paving upon a new principle, in London at least, which has been upon its trial in a great thoroughfare in the city during the last year and upwards. In the early part of 1869 the Commissioners, who, among other functions, are chargeable with the maintenance of the public thoroughfares of the city, consented to a considerable part of the road-way in Threadneedle street being covered with what is called Val-de-travers asphalt, by way of test. This substance has for some years been in use in the streets of Paris on rather a large scale, without, however, being generally adopted. According to a letter written in January last by the Director of Public Ways and Footpaths there, the streets of the first and second arrondissements, comprising an area of about 100,000 square metres, will shortly be asphalted, the crossings being made of stone cubes. Comparatively speaking, he says, the streets asphalted during the last ten years have shown very good results, and such as tend to solve the problem so often propounded—namely, to construct carriage ways possessing the same advantages as those formed of granite or macadam, but without their drawbacks. The asphalt possessing a smooth surface, vehicles easily travel upon it without noise. Besides, it has the further advantage of creating neither mud nor dust, and is not slippery if properly cleansed. That in substance is the testimony, founded on experience, of the French authority to whom reference has been made. This month according to the "Moniteur Officiel" of the 15th ult., will see an extension of the asphalt roadways in the centre of Paris. The Place Louvois, the Rue Richelieu, on the part adjoining the Boulevards, and the Rue Vivienne are to be successively finished. Last year, it adds, an important part of the city was so transformed, and the whole of the district in question will receive this great improvement during the next year. In the city of London upwards of 100 owners and occupiers of premises in Old Broad street, assessed to the consolidated rate at a sum exceeding £45,000—a district long enviable for its comparative quietude—have lately memorialized the Commissioners of Sewers, urging upon them the necessity of paving it with asphalt as a remedy for the daily increasing noise and tumult consequent upon the establishment of the railway terminus at the northern end of that thoroughfare and the augmented traffic, which they say has become a great and serious annoyance to men engaged in mercantile and professional pursuits. They point for relief to the experiment in Threadneedle street, which they say has been found to answer so well, and has proved infinitely preferable to granite or any other paving now in use. In addition to the owners and occupiers in Old Broad street, several hundred firms, including bankers, merchants, stockbrokers, solicitors, and others, around the Royal Exchange and the Bank of England, have petitioned the Commissioners to the same effect. Besides being perfectly noiseless and free from dust and mud, a road so composed is said to diminish in an extraordinary degree the draught on horses. It is also remarkable for economy and durability. The experiments of yesterday are understood to have shown the wear in the pavement in Threadneedle street, although in constant use for more than a year, to have been hardly perceptible. Again, we are assured, in no case does a street once so paved require to be taken up again, except for underground repairs, and the expense of maintenance is very much less than that of macadam. It is also unaffected by heat or frost. In the formation of roads on this principle the rock is first ground, and then, having been subjected to a strong heat in a revolving boiler, by which it is not melted, it is, when in the form of powder, spread on concrete specially prepared, and being compressed with hot irons and rollers, consolidates as it cools into a mass of rock, impervious to wet, and without any joints or seams. Yesterday two pieces, each about 1 ft. square and 2 in. thick, were cut out from the roadway in Threadneedle street, in places where the traffic was supposed to have been greatest, and the result went to

show the least imaginable reduction in the thickness of the substance from wear, and the rapidity with which the roadway was afterwards reinstated in those places appeared to surprise every one who witnessed the operation. It was effected in the presence of Messrs. Callender and Amos, the managers of the Company, at whose sole expense the experiment has been made, and of Mr. Haywood, the engineer, who has to report upon the subject to the Commissioners of Sewers.

A MOUNTAIN RAILWAY IN HUNGARY.

From "The Railway News."

At a moment when the construction of cheap railways has received a new impulse through the Fairlie system, your readers may be interested in hearing of a new invention in this direction by a Hungarian gentleman, Mr. Lopresti, which was tested a few days ago, and with complete success.

There has been, indeed, for the last two years, a trial line, after this system, in use on the property of Archduke Albrecht, near Teschen, in Silesia ; but, being only about 2,000 yards in length, it gave no measure of the applicability of the system on a larger scale.

In the north-eastern part of Hungary the Crown has the extensive domain of Diriggöi, occupying a great portion of the slopes and valleys of the Pike-mountain chain, one of the three detached ranges of mountains in the heart of Hungary. The chief wealth of this domain consists of the fine oak and beech woods, which have been, however, hitherto so badly managed that they not only yielded no revenue, but scarcely paid their cost. Since the Hungarian Ministry was constituted, Mr. Lonyay, the Minister of Finance, has directed his special attention to these Crown domains. One of his creations on this field is the extension of the primitive iron-works of Diriggöi into a large establishment for the manufacture of refined iron. Partly to supply fuel for this, and partly to facilitate the transport of the wood into the neighboring country of the Theiss, a line of about 5 English miles in length has been constructed on one of the mountain valleys to the top of the ridge. The tracks were so wretched and steep, and the line so much curved, that it was quite impossible to bring down the wood by ordinary means without enormous expense. So, on this point the new system has been tried.

The line requires no permanent way at all. Square beams of oak 8 in. high and 14 in. broad are laid on the ground, and only at rare intervals, where the great unevenness of the ground absolutely requires it, cross sleepers are laid under it. Each of these longitudinal beams has a length of 18 ft. ; on the two edges of the beams are the rails, which are only 2 in. broad, and so thin that they weigh but 1 lb. per foot. These beams and rails may be taken up at any moment, and the railway thus relaid whenever it is required. The trucks run on two pairs of wheels 8 in. in diameter ; the bodies of the trucks are about three times the width of the rails, and are placed so low on the wheels that they have just room to pass over them. This, in itself, bringing the weight down so near the line, is a great guarantee against any accidents arising from the narrowness of the gauge and the severity of the curves. Besides this, there is a double brake on each truck, the ordinary brake, and then, before and behind, a couple of side wheels running outside the gauge, which may be pressed against the sides. All these precautions are taken to insure against any overturning, for on parts of the line about half of the truck is hanging over precipices, and running at the rate of some 20 to 30 miles an hour down-hill.

The top of the mountain ridge is some 700 ft. above the level of the valley, where the works are ; for about $\frac{1}{3}$ of the distance of 5 English miles the gradient is but slight—1 or 2 in 100 ; but, further, there are gradients of not less than 1 in 16, and that for considerable distances. Even bolder are the curves. The line winds along the sides of the hills so small that there are curves of a radius of 12 yards, and those of 20 to 22 yards radius follow each other in quick succession. The trucks are taken up empty by horses, and when filled are allowed to come down by

their own impetus. The arrangement of the weight and the system of brakes is so perfect that the train may be stopped when on a gradient of 1 in 7, and going at the rate of 20 to 30 miles an hour, within 6 or 8 yards. The 5 miles cost £2,000, and after the experience now gained the work may be done for about £200 per mile.

As you may gather from the foregoing description, the object of the line in the present instance is traffic one way. And already in this respect it is invaluable in a country like Hungary, which possesses great mineral wealth and forests of inestimable value, which will become accessible at a small cost by these means, whereas otherwise they would be either altogether lost or at least imperfectly got at.

According to the calculations made since the line was opened, the square measure of wood, the transport of which cost from 4 to 5 florins, and at times could not even be transported for that sum, can now be sent down for less than one-half, and in this the sinking fund for the money invested is included. As soon as the woods along the line are cut down the line will be taken up and relaid elsewhere.

But the invention is but half complete, for the inventor has likewise designed a locomotive for his line, which will dispense with the application of horse-power, and will give the invention its full value. He has not had the means of constructing his locomotive, but now a company is to be formed, which will carry out on a large scale what answers so well on a small one. Incomplete as the system is up to the present moment, it is already of great value to Hungary. There are miles and miles of mountain forests which decay for want of means of transport, and which may be utilized by this system. The direction of the State domains has already decided to apply the system to several other domains, and others will no doubt follow. But the utility of this new system is not confined to mountain districts. There are those immense Hungarian alluvial plains, where for miles and miles not a trace of stone is found, and where an ordinary road in some cases costs as much as an ordinary railway, and is then not of much use in autumn and spring. So desperate is the case, that in some instances people have been driven to adopt the so-called clinker, or paved brick road. The laying down of lines on the Lopresti system would almost amount to the same sum as for the transport of the road metal for the regular road.

THE ABRADING AND TRANSPORTING POWER OF WATER.

From "Nature."

I.—MECHANICAL PROPERTIES OF WATER.

It is not my intention to lay down definite rules or formulæ regarding the flow of water, but rather, by drawing attention to generally acknowledged facts, to throw out suggestions which may serve to lead to the discovery of some general laws of practical use to the hydraulic engineer.

In 1857 a paper was read by me before the Royal Society of Edinburgh, "On the Delta of the Irrawaddy," in which I expressed an opinion that depth somehow affected the abrading and transporting power of water.

My experience of Indian rivers and canals during the succeeding ten years went to confirm this opinion, and before the Institution of Civil Engineers, as well as on two occasions before the British Association in 1868 and 1869, I ventured to give expression to my views of this law, as affecting artificial rivers for irrigation, and the bridging of rivers which flow through the alluvial plains of Northern India.

In the "Artizan" there have appeared during the last six months several short articles bearing on the same subject, showing how all questions relating to flowing water are affected by this supposed law, which may be stated as follows: "*The abrading and transporting power of water increases in some proportion as the velocity increases, but decreases as the depth increases.*"

The first question that arises in this inquiry is—What is water in a mechanical point of view?

This may be briefly answered by saying that it is a fluid, the particles of which,

though easily separated, do again unite, and exert a certain affinity towards each other, and also to other bodies, so that a certain amount of power is necessary to effect a separation. The attraction of the particles of water to other bodies varies with different substances; for instance, in all bodies of a fatty nature the facility for wetting is very slight; and different temperatures also affect this property of water. This attraction or force is technically known as "skin friction," and deserves the most careful investigation; for it is owing chiefly, if not altogether, to the fact that water has the power of abrasion, and it is this property which introduces the most difficult problems that a naval architect has to solve.

The affinity of one set of particles of water to another set, may possibly be measured by noting the size of a drop of water which falls from a wetted surface of a given area. By thus determining accurately the weight of water a given area can support, some approximate results of an instructive character may be arrived at; but what adds to the complication of the question is, that the cohesion of the particles probably differs according to the temperature and the purity of the water experimented on. Thus, when water reaches the boiling point, the affinity, it is believed, becomes very much lessened; and, again, it is thought that with pure or distilled water the particles probably have less affinity to each other than with water less pure. This impurity may arise from various causes; sewage, for example, would probably give much heavier drops from the same wetted area than rain-water, in the same manner that drops of treacle are much larger than those of water; that is to say, the affinity, attraction, or cohesion of the particles is as a general rule increased by the introduction of foreign matter held in solution. With solid matter held in suspension a similar result is obtained, not by increasing the cohesion of the particles of water, but by increasing the surface area wetted; for each grain of foreign matter, be its shape what it may, must have all its surface in contact with the water. This probably explains how a drop of mud should be so much larger than one of water, and, at the same time, it may possibly explain why thick muddy water, or, more properly speaking, liquid mud, with the same section and slope, cannot travel so fast as water.

From this it may reasonably be supposed that when muddy water runs down an inclined plane, the particles cannot, by their own gravity, sink so rapidly towards the bottom as to overcome the power dragging them in a different direction. As a consequence, the flow of water is retarded by having solid matter held in suspension in some proportion according to the loads on large rivers where this proportion may be only $\frac{1}{1000}$ or $\frac{1}{2000}$ part of the weight of water in motion, the retarding force may not be appreciable by the most careful experiments; so when calculating, the discharge may be left out altogether; but with torrents transporting 5 per cent. and more of solid matter, and with the discharge of sewage, it is believed that the retarding power is quite appreciable. The whole question is no doubt a very complicated one; yet by a set of careful experiments, conducted with a view to discover this adhesive power of water, it appears highly probable that an important step would be gained towards the solution of some other difficult but important problems.

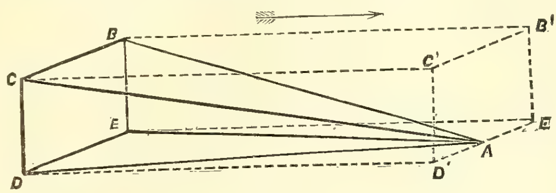
The next point to consider is—How does water travel? This also is a very abstruse question; but I believe that the true answer is given in the brief statement that water *rolls* rather than *slides*.

Were it not so, a ship with a foul bottom could not be so much retarded when passing through the water as experience shows she is. For example, supposing there are two ships in every respect the same, only that the first is covered with a coating of clean pitch a quarter of an inch thick all over her bottom to above her water line; and that the second, in place of the pitch, has got all her bottom covered with marine animals and weeds, so that when this second ship is passing rapidly through the water, none of the sea weeds or marine animals extend more than this $\frac{1}{4}$ in. beyond the ship's sides, which is the thickness of the coating of pitch on the first ship; in such a case the displacement and the lines are exactly the same, but it is hardly necessary to ask any sailor which of the two ships, with the same wind and sails, would pass most rapidly through the water, and, in the case of two steamers, the extra resistance caused by the foul bottom could be easily

measured in extra horse-power required to force the foul vessel through the water at a speed equal to the other.*

If the motion of the water was a *sliding* one only, the speed in both cases would be the same with the same power, for the resistance would be simply the separation of the two films of water, the one in contact with the ship's sides and the other with the surrounding sea ; and these, in both cases, would be identical, the displacement being the same. If, however, as is believed, on a body passing through water, or water flowing down a channel, the particles of water are set in motion in a revolving direction, the convolutions increasing directly in proportion to the wetted surface, then by this hypothesis some assignable reason for this retarding of the foul-bottomed ship can be given.

If the particles slid over each other rather than rolled, they would, so to speak, pass each other in parallel straight lines ; but any one in a gale of wind, going behind a high square block of building, would very soon discover that, in air, such is not the case ; for if he went a few yards away in the direction the wind was blowing, he would soon discover that the building no longer afforded any protection from the blast, but that there was some certain point to leeward where the currents again converged, while beyond this the storm raged with the same violence as at any other point. (Every boatman knows what it is to get under the lee of a very high island ; the sea may be smoother, but the sudden gusts of wind are often more dangerous than when exposed to the full force of the gale.) Immediately in rear of the wall itself he would find eddies of air whirling about in all directions. Within the space, A B C D E, there would be a partial protection from the storm, and instead of the wind being in the direction shown by the arrow, there would be whirling eddies



within this space, which could not exist were the air to pass off in straight lines as represented by the dotted lines B B′, C C′, D D′, E E′; neither could the several currents of air converge at the point A, which it is well known is always the case.

In the same manner any obstruction placed in a stream of water causes eddies in rear of it ; that is to say, the water does not pass on in straight lines, but within this space it goes revolving about in all directions, the distance of A probably depending on the velocity ; showing that there is neither a sliding motion nor a parallelism in the direction of the lines of current.†

II.—FRICTION OF WATER.

How does flowing water obtain this rolling motion ? The reply to this is, By *friction.*

Take, for example, the rifling of a gun ; we all know that it is owing to the spiral grooves or prominences in the chamber that the shot gets its spinning motion ; but supposing the shot be a sphere, and fired from a smooth bore, it has not this rotatory motion at right angles to the line of flight, and no great dependence can be placed on its accuracy, but it may rise or fall, pass to the right or left, all depending on which side of the gun's mouth the shot touched when passing out, for so will it revolve. Should it ricochet, it will, when nearly spent, be observed to roll over the ground, and this is all caused by the friction offered by the resistance of the ground with which it came in contact. And what reason can there be assigned against water adopting this most simple of all laws for bodies in motion ; and is it not owing to this that water in a cistern takes a circular motion when escaping through an orifice in its bottom, or pre-

* Possibly by the introduction of an elastic medium, such as air, between the ship's bottom and the water, the skin friction may be reduced, as it may, in a measure, reduce this rotatory action.

† By an experimental study of this subject, it may be discovered how far these eddies extend with different velocities, which may throw light on the proper length of the after portion of ships intended for different speeds.

sents a cork-screw appearance when poured out of a small vessel? Again, on the large scale, with rapid currents such as in the Pentland Frith, what but this circular motion of the stream can cause that boiling appearance given to the water, which every one must have observed who has navigated waters where there is a strong tideway? And cannot this explain why there should be an enormous breaking sea at the point where the heavy swell of the Atlantic meets the ebb tide; and does not this rolling motion given to the tide, acting in an opposite direction, check the oscillations of the Atlantic swell, causing those huge breakers so well known to the Orcadian boatmen?

Supposing every particle of water to be a sphere in itself that can roll independently, and that a number of them being collected together form a larger sphere, which also rolls, and so on, then the diameter of the spheres increases with the depth, be it ever so great. Consequently, the facility for rolling will also increase, so that the deeper and broader a stream is—that is, the farther the centre of a stream is from the retarding medium (the bed and banks of a river)—the less is this rotatory motion obstructed; and does not this explain how the velocity increases with the hydraulic mean depth? The air also has a retarding effect even in a perfect calm; for where the Mississippi was very deep, it has been observed that the greatest velocity was not at the surface, but at some distance below it.

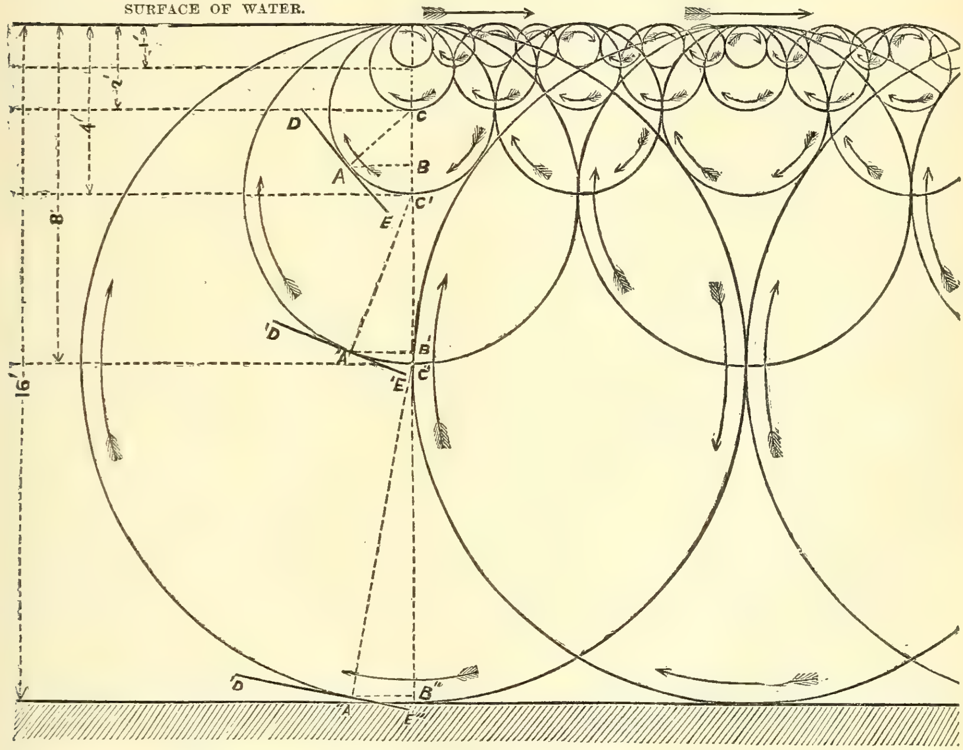
Supposing that water moves in an innumerable number of circles, varying from a single particle in diameter to that of hundreds of feet, and that every obstruction sets these circles revolving at right angles to their surfaces, we can at once begin to understand how, by increasing the areas exposed to friction, an innumerable set of wheels of various sizes are set spinning in all directions, but are retarded in this action by the attraction of the several particles to each other. Thus, wheels within wheels will be set in motion, some revolving in opposite directions; and the quicker the revolutions—that is, the smaller the diameter of the wheels, in other words the shallower the stream—the greater will be the power expended, which power Nature exerts in holding solid matter in suspension; therefore, if the foregoing arguments be correct, it is evident that the transporting and abrading power of water must increase in some ratio inversely as the depth, and that the retarding of a ship's sailing on a flowing river must depend on the increased area of surface exposed, thus explaining why a ship with a foul bottom, a rough, rocky bed to a river, or weeds in a stream, all retard velocity, because they one and all set so many more wheels spinning. This leads us to the important questions where abrasion and the power of flowing water to hold solid matter in suspension have to be investigated, with the view of showing how this rotatory motion acts in nature. To do so the following diagram will perhaps give a slight idea of the complicated nature of this rotation, the circles being supposed to increase in diameter with the depth. This diagram is only intended to show the relative motion of one set of particles with respect to its neighboring set of particles, each for its own depth of 1, 2, 4, 8 or 16 feet deep. Thus, where the depth is 16 feet, there would be a series of circles 16 feet in diameter, rolling within each other, where the depth was 8 ft. there would be circles of 8 ft. in diameter, and so on. That is, with the same velocity, the rotation would decrease as the diameters became greater.

The various angles with the horizon are represented by the lines D E, D′ E′, and D″ E″, which show the necessary slopes, in order that the centre of gravity of each circle should be equally beyond the point of support A′, and that consequently A B, A′ B′, A″ B″, should be all equal; they indicate that where the slope of the surface of the water remains in each case the same (say, for example, one foot in a mile), the velocity probably increases proportionally to the increased hydraulic mean depth, or that where the velocities are the same, and the depths differ, the slope requires also to vary. Let, for example, the velocity be in each case about 5 miles an hour, or some $7\frac{1}{2}$ ft. a second, while the depths are 5 ft., 8 ft., 10 ft., and 90 ft. respectively, the slopes vary from 25 ft. in the mile to only some 4 inches, while the load of solid matter held in suspension is about 7 per cent., 5 per cent., 3 per cent., and only $\frac{1}{1700}$ of the weight of water in each of the above cases respectively. With the assistance of the diagram, therefore, it will at once be seen how the whirl-

ing motion given to a stream must increase as the depth decreases, and how, by the increased agitation, the water is able to hold proportionally more solid matter in suspension, while the action on the bed of the channel must at the same time be increased.

To carry this action to extreme cases it appears evident that where the velocities are considerable, and the depths only a foot or two, the slopes must become almost precipitous, while the stream must become semi-fluid mud, or transport a large proportion of boulders, and even rocks ; in doing which a certain amount of power must be expended, and in transporting this solid matter this loss of power cannot but retard the flow of the stream. On the other hand, it may be assumed that, even with considerable velocities, which at small depths would tear up and hurl forward rocks, boulders, sand and mud, with excessive depths the water may flow on in almost a comparatively pure state, and instead of holding in suspension stones and coarse sand, can only transport fine particles of mud.

SURFACE OF WATER.



BOTTOM OF CHANNEL.

III.—PRACTICAL CONCLUSIONS.

The following conclusions may now be arrived at :

I. That all particles of water have an affinity to each other as well as to other bodies, and that force is required to separate them.

II. That friction sets these particles rotating in all directions in larger or smaller circles, and that the friction or force increases in some proportion to the area of surface exposed.

III. That this rolling motion becomes rarer the larger the diameter of the circles may be, that is, the resistance decreases as the depth and breadth of a stream increase, or, in other words, the velocity increases proportionally to the "hydraulic mean depth."

IV. Lastly, that any increase to the rapidity of this rotatory motion, must increase the abrading and transporting power of water, by enabling it to remove from the channel of a stream grains of

solid matter, and hold them in suspension.

The following deductions are arrived at:

1. That a smooth surface offers the smallest area for the water to attach itself to, and fewer irregularities; consequently the rotatory motion given to the water is reduced to a minimum, that is, the power expended is least, or the friction among the particles of water flowing through a smooth uniform channel is less than when it flows through an irregular and rough one.

2. That in the lines of a ship not only should there be no sudden changes in direction, but the surfaces should be as smooth as possible.

3. That the area of this surface should be as small as possible; hence convex lines are preferable to concave ones, as with the same area they afford greater buoyancy, while there would be less friction for the water to roll along a convex surface than a concave one.

4. That additional length given to a ship, leaving out all other questions, must retard a ship passing through the water, by increasing the area exposed to friction; consequently there is probably some limit owing to this increased resistance, where the length midships should not exceed certain proportions of the midship section.

5. That a ship passing over shallow water must be retarded, as the diameter of the vertical circles revolving under her bottom must be less than the diameter of the circles where the water is deep; hence the smaller circles will be set in quicker rotation, and therefore loss of power ensues.

6. That the same will be the effect from the same cause where the channel is narrow and contracted.

These deductions apply to cases where the abrasion may be considered "nil," such as the discharge of water through pipes, and the sailing of ships; and the practical conclusion is, that for pipes with glazed surfaces, and ships having coppered bottoms, the water passes with the least friction.* In the case of ships, *speed* is not the only question to be considered; so the subject becomes very complicated, and though believing in the general soundness of the above deductions, the solution of these problems may be left to the naval architect to consider.

Viewing the subject on the large scale, very important conclusions are arrived at from these facts—namely, that the depth of a river depends on the nature of the materials it has got to transport; thus those which have to carry down coarse sand should be broad and shallow, while those which have to convey fine mud would naturally be narrow and deep. And as this depends on the geological nature of the catchment basin of the river, are we not naturally led to the conclusion that where we find rivers navigable, the rocks of the catchment basin which predominate are of an aqueous formation, while those rivers which are difficult of approach from the sea must drain a country where crystalline rocks predominate? Judging, therefore, on this hypothesis, are we not right in conjecturing that the rocks of Central India, and also of that vast, but hitherto almost unexplored, country, Central Africa, must be generally of a crystalline nature?

This interesting question, however, like that of the best form of ships, had better be left for the consideration of the professional inquirer, whose investigations lead him to study that branch of geology which treats of the denudation of rocks now going on on the earth's crust, and the deposits now being formed. I pass on to those questions which affect the hydraulic engineer, and they are so numerous that it would be difficult even to enumerate and classify them, while their importance is so great that it can hardly be overestimated. On this occasion only one or two of the more prominent subjects will be glanced at, more for the purpose of leading to future investigation, than to lay down rules for guidance, which at this present stage it would be premature to attempt.

* On reading over the above conclusion to an experienced ship-builder here in London, he said that one of the reasons why Aberdeen clippers sailed so fast, was owing to the smoothness of the ships' bottoms, which were first planed before the copper was put on. He also remarked that where the copper is very smoothly put on, the first place where the sheet wears through is just behind where the sheets overlap, showing that even an irregularity of one-sixteenth of an inch causes an extra action, not as might be supposed at the point of greatest obstruction, but just beyond it, proving that there must be this whirling motion which causes this abrasion. This gentleman also observed that experience showed that the speed of a ship chiefly depends on the fineness of the lines of the after rim of a ship, and that "ingoing" or concave lines should be avoided if possible.

From the foregoing remarks, suggestions, and deductions, it may be supposed that there are certain laws of nature which adapt each case to its own particular circumstances. Take, for example, the course of a river. It has been before said that streams which have to transport coarse, solid matter, such as sand, are usually broad and shallow, while those which convey chiefly fine mud are deep and narrow. The reason why those streams which convey a large proportion of sand should be broad and shallow, is that the water has thus sufficient power to hold the solid matter in suspension; and to still further aid them in this, it will be often observed that Nature generally gives such rivers, comparatively speaking, straight channels, in comparison to those which convey fine mud. The object in this case would appear to be that Nature in the former instance takes the shortest route, so as to obtain as great a fall as possible in the bed of the stream; while with the deep muddy stream, to prevent the water rushing off too fast, and so to keep up the surface of the stream to a level with the banks, or in floods often above them, Nature takes her tortuous courses, and is thus enabled year after year to deposit those fine grains of mud which add so much to the fertility of the soil.

So evidently is this the case, that in Egypt the irrigation canals are all carried in a zigzag direction, so as to check the velocity, and prevent the coarser particles of sold matter from being transported, while at the same time the surface of the water is kept at a sufficient elevation, so as to admit of easy irrigation. Thus, probably, Joseph, or whoever started irrigation in the land of the Pharaohs, took a leaf out of Nature's book; and it is by the study of this volume that the engineer of the present day will be most certain to arrive at satisfactory results.

That rivers have certain general principles by which they are governed, as to breadth, depth, slope, velocity, and load of solid matter held in suspension, it appears reasonable to suppose; and any change introduced in any one of these proportions must cause a corresponding change in one or all of the above conditions.

Thus, let there be a stream which in flood contains 5 per cent. by weight of solid matter, and let it be 8 ft. deep, discharging 50,000 cubic feet a second, with a mean velocity of $7\frac{1}{2}$ ft. a second—the breadth of this stream would be $\frac{50.000}{8 \times 7.5} = 833\frac{1}{3}$. To add one-fourth to the discharge of this stream of pure water would increase the discharge from 50,000 to 62,500 cubic feet a second, and the proportion of solid matter, instead of being 5 per cent., would be only 4 per cent. But, by the example before given, a depth approaching 9 ft. instead of 8 ft. would be the natural depth, so the bed would be lowered 1 ft., and the breadth would only be increased $\frac{12.500}{2 \times 9 \times 7\frac{1}{2}} = 92$ ft., instead of having to give an increase of one-fourth more, or $\frac{833}{4} = 208$ ft., and still keep matters much as they are found in nature.

So in bridging such a stream the whole additional length of viaduct would be only 92 ft., or 116 ft. would be saved by simply sinking the foundations 1 ft. more. But as water rolls rather than slides, and never flows in straight lines, the shape of the section of a stream can be changed at pleasure; so the depth may be increased without much danger by decreasing the breadth. Taking, then, the same stream which it was proposed to make $833 + 92 = 925$ ft. broad by 9 ft. deep, suppose the mean depth be made 15 ft., this increase of depth would decrease the transporting power, while at the same time the velocity would also be increased; and suppose it to be now 10 ft. a second, instead of $7\frac{1}{2}$ ft., and with a depth of 15 ft. with such a velocity only 4 per cent. of solid matter could be held in suspension, and the waterway would be $\frac{62.500}{15 \times 10} = 416\frac{2}{3}$ ft. broad, instead of 925 ft., or less than one-half; that is, by adding 8 ft. to the general depth of a stream where the river discharges 50,000 cubic feet a second in the main channel, and 12,500 cubic feet a second of inundation water, which is comparatively free of silt, the whole volume of 62,500 cubic feet could be passed through a bridge only half the breadth of the original stream, which was 833 ft. broad. So the whole question reduces itself now into one of cost..

The question is, whether it be cheaper to sink the foundations an extra 8 or 10 ft., or to double the length of viaduct. By

the use of the sand-pump, foundations can now be sunk through sand at a very moderate cost; so it is believed that the extra sinking would not involve anything like the cost of the shallower foundations for the bridge built on the extended plan; thus the whole cost of the superstructure and extra girders could be saved—that is, speaking approximately. In such a case the bridge built on this deep foundation principle could be built at nearly half the cost of the old plan; but to guard against accidents, and scooping out to excessive depths, it would appear that at least one-third may be saved by building bridges on this principle; while the river, by having a deep channel under the bridge, could be kept in better control than by the present extended method, as it would not have such a tendency to desert its course, but would always keep to the deep channel.

Several other examples may be brought forward to illustrate the practical advantages that a better knowledge of the action of flowing water would be sure to confer on science and hydraulic engineering; but it is hoped that the foregoing will assist in bringing the importance of the subject more prominently forward. When once the subject is properly discussed I am convinced its importance will be manifested.

T. Login.

EXPERIMENTS FOR MAKING BRICK MASONRY IMPERVIOUS TO WATER.

Abstract of a paper read before the American Society of Civil Engineers, May 4, 1870, by William L. Dearborn, Civil Engineer, Member of the Society:

The face walls of the Back Bays of the Gate-houses of the new Croton Reservoir, located north of Eighty-sixth street, in Central Park, were built of the best quality of hard-burned brick, laid in mortar composed of hydraulic cement of New York, and sand, mixed in the proportion of one measure of cement to two of sand. The space between the walls is 4 ft., and was filled with concrete. These face-walls were laid up with great care, and every precaution was taken to have the joints well filled and insure good work. They are 12 in. thick and 40 ft. high, and the Bays, when full, generally have 36 feet of water in them.

When the Reservoir was first filled, and the water was let into the Gate-houses, it was found to filter through these walls to a considerable amount. As soon as this was discovered, the water was drawn out of the Bays, with the intention of attempting to remedy or prevent this infiltration. After carefully considering several modes of accomplishing the object desired, I came to the conclusion that the mode known in England as "Sylvester's Process for Repelling Moisture from External Walls," was the easiest of application, and would be as effectual as any; and, on consulting Dr. Chilton, the chemist, I was confirmed in this opinion.

The results of the investigation were then submitted to A. W. Craven, Engineer of the Croton Water Works, for his decision, and his instructions were to adopt Sylvester's process.

This process consists in using two washes or solutions for covering the surface of brick walls; one composed of Castile soap and water, and one of alum and water. The proportions are: three-quarters of a pound of soap to one gallon of water, and half a pound of alum to four gallons of water, both substances to be perfectly dissolved in the water before being used.

The walls should be perfectly clean and dry, and the temperature of the air should not be below 50 deg. Fahrenheit, when the compositions are applied.

The first or soap wash should be laid on, when at boiling heat, with a flat brush, taking care not to form a froth on the brickwork. This wash should remain 24 hours, so as to become dry and hard before the second or alum wash is applied, which should be applied in the same manner as the first. The temperature of this wash, when applied, may be 60 or 70 deg., and it should also remain 24 hours before a second coat of the soap wash is applied, and these coats are to be repeated alternately until the walls are made impervious to water.

The alum and soap thus combined form an insoluble compound, filling the pores of the masonry and entirely preventing the water from penetrating the walls.

Before applying these compositions to the walls of the Bays, some experiments were made to test the absorption of water by bricks under pressure, after being covered with these washes, in order to determine how many coats the walls would require to render them impervious to water.

To do this, a strong wooden box was made, put together with screws, large enough to hold two bricks, and on the top was inserted an inch pipe, 40 ft. long.

In this box we placed two bricks, after being made perfectly dry, and then covered with a coat of each of the washes, as before directed, and weighed. They were then subjected to the pressure of a column of water 40 ft. high, and, after remaining a sufficient length of time, they were taken out and weighed again to ascertain the amount of water they had absorbed.

The bricks were then dried, and again coated with the washes and weighed, and then subjected to pressure as before; and this operation was repeated until the bricks were found not to absorb any water. Four coatings rendered the bricks impenetrable under the pressure used.

The mean weight of the bricks (dry), before being coated, was $3\frac{7}{8}$ lbs.; the mean absorption was one-half pound of water.

An hydrometer was used in testing the solutions.

As this experiment was made in the fall and winter (1863), after the temporary roofs were put on to the Gate-house, artificial heat had to be resorted to to dry the walls and keep the air at a proper temperature.

The cost was 10.06 cts. per square foot.

As soon as the last coat had become hard, the water was let into the Bays, and the walls were found to be perfectly impervious to water, and they still remain so.

BRICK ARCH (FOOTWAY OF HIGH BRIDGE).

The brick arch of the footway of High Bridge is the arc of a circle 26 ft. 6 in. radius, and is 12 in. thick; the width on top is 17 ft., and the length covered was 1,381 ft.

The arch, for 8 in. in thickness, rests on cast-iron skewbacks, which are prevented from separating by wrought-iron tie-rods.

The two first courses of brick of the arch are composed of the best hard-burnt brick, laid edgewise in mortar composed of one part, by measure, of hydraulic cement of New York, and two parts of sand.

The top of these bricks, and the inside of the granite coping, against which the two top courses of brick rest, was, when they were perfectly dry, covered with a coat of asphalt one-half an inch thick, laid on when the asphalt was heated to a temperature of from 360 to 518 deg. Fahrenheit.

On top of this was laid a course of brick, flatwise, dipped in asphalt, and laid when the asphalt was hot, and the joints were run full of hot asphalt.

On top of this a course of pressed brick was laid, flatwise, in hydraulic cement mortar, forming the paving and floor of the Bridge. This asphalt was the Trinidad variety, and was mixed with 10 per cent., by measure, of coal tar, and 25 per cent. of sand. A few experiments for testing the strength of this asphalt, when used to cement bricks together, were made, and two of them are given below.

Six bricks pressed together, flatwise, with asphalt joints, were, after laying six months, broken.

The distance between the supports was 12 in.; breaking weight, 900 lbs.; area of single joint, $28\frac{1}{2}$ square in. The asphalt adhered so strongly to the brick as to tear away the surface in many places.

Two bricks pressed together, end to end, cemented with asphalt, were, after laying six months, broken.

The distance between the supports was 10 in.; area of joint, $8\frac{1}{2}$ square in.; breaking weight, 150 lbs.

The area of the Bridge covered with asphalted brick was 23,065 square ft. There was used 94,200 lbs. of asphalt, 33 barrels of coal tar, 10 cubic yards of sand, 93,800 bricks.

The time occupied was 106 days of masons and 148 days of laborers. Two masons and two laborers will melt and spread, of the first coat, 1,650 square ft. per day. The total cost of this coat was 5.25 cents per square foot, exclusive of duty on asphalt. There were three grooves, 2 in.

wide by 4 in. deep, made entirely across the brick arch, and immediately under the first coat of asphalt, dividing the arch into four equal parts. These grooves were filled with elastic paint cement.

This arrangement was intended to guard against the evil effects of the contraction of the arch in winter, as it was expected to yield slightly at these points and at no other point, and then the elastic cement would prevent any leakage there.

The entire experiment has proved a very successful one, and the arch has remained perfectly tight.

NOTE BY GEN. GEORGE S. GREENE.

In proposing the above plan for working the asphalt with the brickwork, the object was to avoid depending on a large continued surface of asphalt, as is usual in covering arches, which very frequently cracks from the greater contraction of the asphalt than that of the masonry with which it is in contact, the extent of the asphalt on this work being only about one-quarter of an inch to each brick.

This is deemed to be an essential element in the success of the impervious covering.

THE STRENGTH OF IRON AND STEEL.

From the "Building News."

At the last meeting of the Institution of Civil Engineers a paper was read "On the Strength of Iron and Steel, and on the Design of parts of Structures which consist of those materials," by Mr. George Berkley.

The author stated that the strength of wrought-iron varied with the quantities of work involved in the production of the form of the material tested. This was proved by the fact that a bar of iron 1 in. sq., which would break with a strain of 26 tons, would, if drawn to the form of wire $\frac{1}{32}$ of an in. in diameter, bear a strain of 40 tons per sq. in. The strength to be relied on in practice would probably be best represented by the minimum strain that 1 sq. in. would bear without rupture, and by the amount of stretch which would take place in a given length before it broke. Iron could be obtained at the current market rates which would bear the following strains: For plates, an average breaking strain of 20 tons per sq. in., and a minimum breaking strain of 19 tons per sq. in., and an average stretch of 1 in. in 12 in. lineal. For L and T irons an average breaking strain of 22 tons per sq. in., and a minimum breaking strain of 21 tons per sq. in., and an average stretch of $1\frac{1}{4}$ in. in 12 in. lineal. For rivet iron an average breaking strain of 16 tons per circular in. For bars intended for chains, couplings, etc., an average breaking strain of 22 tons per sq. in., and an average stretch of $1\frac{3}{8}$ in. in 12 in. lineal. For ordinary classes of work, let at competitive prices, stronger iron could only be obtained with difficulty.

In the consideration of the practical limit of strain to which 1 sq. in. of wrought-iron could with safety be subjected, and the principle on which such a limitation rested, the erroneous impression as to the degree of strain being 10 tons or 12 tons per sq. in. which first produced "permanent set" was pointed out, as well as the apparent discrepancy between the results of ordinary observation and of minutely manipulated experiments, such as those of Sir Wm. Fairbairn and Mr. E. Clark, was noticed, wherein permanent set had been observed after 3 tons per sq. in. had been imposed on the iron, and was explained by the difficulty of registering such small amounts of set as $\frac{1}{1250}$th part of an in. in 5 ft., which resulted from a strain of 10 tons per sq. in.

Attention was drawn to the fact that upon the application to 1 sq. in. of wrought-iron of strains exceeding about 12 tons, the measure of stretch per unit of strain, which had previously increased in a certain proportion to the units of strain applied, increased with a greater and progressive rapidity. It was also noted that the amount of stretch actually produced by the imposition of a strain of about 12 tons per sq. in., would be sufficient frequently to preclude the use of wrought-iron so strained.

In illustration of the effect of the repetition of strains on iron and steel, it was stated that with blows powerful enough to bend bars of cast-iron through one-half of their ultimate deflection (that was to say, the deflection which corresponded to their fracture by dead

pressure) no bar was able to stand 4,000 of such blows in succession. And also, that when the bar was thrown into a violent tremor, then "when the depressions were equal to one-half of the ultimate deflection, the bars were broken by less than 900 depressions." A piece of rail, weighing 68 lbs. per yard, made of Bessemer metal, which, when placed on firm bearings 3 ft. apart, bore one blow from a weight of 1 ton falling through 30 ft. without breaking, though bending about 7 in., broke with a weight of $3\frac{3}{4}$ cwt., falling 15,400 times through heights increasing from 1 ft. to 10 ft. by increments of 6 in. each time. With wrought-iron, it appeared from an experiment of Sir Wm. Fairbairn that when it was desired to repeat the application of strains from 2 to 3 million times it would not be prudent that such strains should exceed 7 tons per sq. in. of section.

It appeared from these considerations that the practical strength of wrought-iron in structures of a permanent character could not be estimated at more than 12 tons per sq. in. when such an amount of strain was repeated more than a small number of times ; and that it should not be calculated as exceeding 7 tons per sq. in. when strains of this amount would be applied to it many times daily. In some of the principal suspension road bridges, it was said that a maximum of about 9 tons per sq. in. of section in tension was imposed on extraordinary occasions, while railway bridges were frequently subjected to the maximum calculated strain, a limit of 5 tons being in this country generally adopted. From this practice it was assumed that a margin, for errors of design and for other practical defects, of only 25 per cent. was allowed in permanent structures. The importance of sound principles of design was therefore manifest. The parts most difficult to design were the connections of portions of the structure with riveted joints. It was desirable that the area of the section of the rivets to be sheared, as well as of the plates forming these connections, should be somewhat in excess of the sectional area of the plates or bars which they connected; and that as the process of punching the rivet-holes in the plates, etc., had a tendency to weaken them in a greater proportion than that in which the area was decreased, it was advantageous to drill all rivet-holes in parts exposed to tension. It was represented that the general principles of design were well illustrated by a joint made of a single pin, such as that used in suspension bridges, Warren girders, etc. Examples of various forms of links were presented for consideration, and a form of link of equal thickness, but with an enlarged head, was said to have been proved by experiment to be of about equal strength in all its parts. The proportions of these links were as follows:

The bar........................	A	being	100
The diameter of pin..............	B	=	74
The depth of head beyond pin.....	C	=	100
The two sides of the pin-hole.....	D D	=	125
And the radius of the curve of neck.	R	=	150

Links of these proportions, with larger pins and narrower sides—Nos. 7 and 7a—and larger pins and sides of the same width, Nos. 8 and 8a, made of iron of exactly the same strength, and links of proportions precisely similar to those adopted for the Menai, Nos. 9 and 9a, the Pesth, Nos. 10 and 10a, the Chelsea, Nos. 11 and 11a, and the Hungerford, Nos. 12 and 12a, were compared. Taking the strength of the standard form, 22,125 tons per sq. in. of bar area, as = 100, the percentage of gain or loss in power of resistance to ultimate strain by the use of the other forms of links as follows :

6 and 6A	= 100			
7 " 7A	= 79.9;	loss	= 21.1	per cent.
8 " 8A	= 104.7;	gain	= 4.7	"
9 " 9A	= 92.0;	loss	= 8.	"
10 " 10A	= 79.8;	"	= 21.2	"
11 " 11A	= 89.2;	"	= 10.8	"
12 " 12A	= 85.4;	"	= 14.6	"

The necessity for strengthening the heads of links, and for testing all of them with a strain equal to at least 10 tons per sq. in. of bar, was proved, it was believed, by the experiments quoted, and by the evidence of Mr. Provis in his work on the Menai Bridge. It was urged that an examination of the diagrams would show that some links failed with a less degree of stress, on account of the junction of the mass of the head with a comparatively smaller section of bar, by means of a curve of too short radius. This imperfect principle of construction also operated in causing fracture across the centre of the heads on both sides of the pin-hole ; and in such designs, the question of the direction of the strain being truly along the axis of the link or

bar, and of the strength of the material on both sides of the head being equal, should be considered.

The author next directed attention to the unsatisfactory state of the knowledge of the profession respecting the power of struts of various proportions and forms to resist compression, and stated his belief that the formulæ which had been proposed to facilitate calculations for determining the strain which such columns would bear, produced results which neither agreed one with the other, nor with any series of such experiments as had been tried. It seemed probable that for the present, error might be best avoided by referring to the results of experiments made upon columns, etc.; the conditions of which were analogous to the case under consideration.

With respect to cast-iron, it was stated that a mixture of iron for sleepers had produced bars, 2 in. by 1 in. in section, which, when placed on bearings 3 ft. apart, had on the average of 1,151 experiments during the last three years borne 33.4 cwt. placed on the centre, and castings, 1½ in. in length and exactly 1 in. square, which on the average of 1,002 experiments had borne 13.07 tons of tensile strain. An attention to the amount of deflection of the test-bars had been beneficial, the average strain required to break the sleepers have been raised since the amount of deflection of the bars with a given weight had been increased. For the purpose of comparing the comparative strength of precisely similar girders cast with iron of varying degrees of strength, as represented by the ordinary test-bars, and when subjected to a direct tensile strain, the experiments detailed in the Appendix (Table No. 7) were tried, the girders being cast of the exact form and dimensions of three of those described in Sir William Fairbairn's "Researches on the Application of Iron to Buildings." The results were as follows:—

The strength per square inch of section was represented in Girder No. 1, by

Mr. Fairbairn's experiments...... as = 3214 lbs.
The first series of special experiments.................... as = 4977 "
The second series of special experiments........................ as = 4977 "

In Girder No. 2 by

Mr. Fairbairn's experiments ...... as = 3346 lbs.
The first series of special experiments .... as = 5264 "
The second series of special experiments .... as = 5308 lbs.

In Girder No. 3 by

Mr. Fairbairn's experiments ...... as = 4075 lbs.
The first series of special experiments .... as = 4988 "
The second series of special experiments........................ as = 6300 "

The strength of the test-bars and the tensile strength of the iron used by Sir Wm. Fairbairn was not stated; but it might be assumed to be equal to about 25 cwt. placed on the centre of the bars, between bearings 3 ft. apart, and to a tensile strength of about 7 or 8 tons per square inch. The strength of the iron employed in the special experiments was represented by a weight supported by the test-bars varying from 30 cwt. to 38 cwt., and by a tensile strength varying from 10.25 tons to 13.94 tons.

In order to secure these results, the following conditions were represented as important, and should be considered in the design and execution of cast-iron work:

1*st.* The strong iron referred to was obtained by the mixture in the furnace of four or five brands, some being harder than others. In order to amalgamate, as far as possible, these different qualities of iron, the furnace should be charged with them mixed in proper proportions in every basketful of metal which was emptied into it. 2. There would be a difference of about 16 per cent. between the weight that a 2-in. by 1-in. test-bar would support when cast on edge and proved as cast, and that which it would support when proved with the under-side as cast placed at the top as proved; and a difference of about 8 per cent. between the weight the same test-bar would support if cast on its side or end, and proved on edge. This difference it would be necessary to take into consideration in estimating the strength of a large casting made from the same metal as that used in the test-bars. Another, and probably the most important practical consideration, in respect of the strength of castings, was the proportions of their several parts being such as would free them as much as possible from unequal contraction in cooling. It was not often practicable to effect that which would avoid this, viz., to adopt an equal thickness of metal in all parts of the casting; and it was therefore important that some means

should be taken to prevent the castings from cooling too quickly.

The author drew attention to the experiments which had lately been tried with steel—more especially Bessemer steel—which experiments he considered justified the adoption of the following conclusions:

1*st.* That Bessemer steel would bear before rupture a minimum tensile strain of 33 tons per square inch of section and stretch about 1 in. in 12 in. of its length. 2*nd.* That the same material would bear either in tension or in compression a minimum stress of 17 tons before the extensions or reductions of length per unit of strain became irregular or excessive, as compared with those which had preceded them,—in other words, before the yielding point of the material was reached. 3*rd.* That this material probably contained about .45 per cent. of carbon chemically combined with the iron. And 4*th.* That this description of steel, if properly made and annealed, was as uniform in quality as wrought-iron—and therefore might be employed (precautions being taken to test its quality as a substitute for wrought-iron) while allowing an increase of strain of 50 per cent. to be imposed upon it.

EXPERIMENT ON THE EVAPORATION OF A CORLISS BOILER.

By JAMES B. FRANCIS, Civil Engineer.

The experiment was made on one of the 4 Corliss boilers in the mills of the Merrimack Manufacturing Company at Lowell, Massachusetts, constructed by the Corliss Steam Engine Company of Providence, R. I., and first put in operation in October, 1868.

Each boiler consists of a central cylinder, about 24 ft. high and 42 in. in diameter, standing vertically on the floor of the boiler-house, and containing no tubes or flues, but surrounded by an annular grate, about 12 ft. in diameter, with 8 fire doors on its exterior circumference. Hanging vertically from the sides of the central cylinder, are 6 other cylinders, about 14 ft. long and 40 in. in diameter, each containing 61 vertical tubes, 2 in. internal diameter, and about 14 ft. long. Each of the tubular cylinders is connected with the central cylinder by 3 pipes, about 7 in. long; those near the top and bottom of the tubular cylinders being about 9 in. in diameter, and the intermediate pipe, which is a little below the usual water line, is about 15 in. high and 6 in. wide.

The usual height at which the water is kept is at the 5th gauge cock, which is about 3 ft. below the tops of the tubular cylinders, and about 9 ft. below the top of the central cylinder.

The products of combustion rise on the outsides of all the cylinders to within about $2\frac{1}{2}$ ft. of the usual water line. There is, however, no outlet for the gases except through the 366 tubes in the tubular cylinders; the lower 11 ft. of the length of the tubes being usually surrounded by water, and the upper 3 ft. by steam. After passing through the tubes the gases enter a chamber concentric with the central cylinder, and extending about 14 ft. above the top of the tubular cylinders, giving just sufficient height to take out the tubes. From near the top of this chamber the gases pass off by a horizontal flue of sheet iron, about 6 ft. wide and 1 ft. high, to a chimney, 200 ft. in height.

The 7 connected cylinders forming the boiler are enclosed by a cylindrical wall of brickwork, which confines the gases and supports the feed-water tank. The draft is regulated by means of a damper in the horizontal sheet iron flue, and by the 8 ash-pit doors, which are well fitted, and open into a common ash pit. Usually one of these doors was open from a quarter to a half, and the damper in the flue also open about one half. The fire doors were made of two parallel plates of iron, 2 or 3 in. apart, with 6 air holes, $\frac{3}{8}$ths of an inch in diameter, through the outer plate, and a greater number through the inner plate; said to be for the purpose of preventing the doors from becoming too much heated. The powerful draft causes a large quantity of air to pass through these holes and enter the space above the fire, apparently much in excess of what is necessary for the combustion of the gases.

The top of the chamber is covered by an open tank about 18 in. deep, in which the feed water is usually heated, but

which was not used for that purpose in this trial.

The passage of the heated gases over surfaces of the boiler above the water line, of course, tended to superheat the steam, and observations of the temperature of the steam, as well as its pressure, were made to ascertain the amount of the superheating.

The amount of the heating surface, not including the feed-water tank, is as follows :

	SQ. FEET.
Area of heating surface on outside of the 7 cylinders, connecting pipes, etc..	1277.56
Tube surface	2679.01
Total heating surface................	3956.57
Area of grate surface	103.27
Fire surface to each square foot of grate surface	38.31
Usual thickness of fire 6 to 8 in., average about	7 in.

For convenience of feeding with water from the water tank, the north-easterly boiler was selected for trial. I am informed that this boiler has been in use uniformly since it was first started, stopping regularly with the others, one week in four, for cleaning and examination. It was stated by Mr. Austin, the engineer in charge, that this boiler was blown off last four or five weeks before the commencement of the trial. It had been stopped one week in its turn just previous to the commencement of the trial, during which time the water was drawn out of it, and the fire surfaces of the tubes and other parts cleaned; nothing, however, being done beyond the usual monthly cleaning.

The trial consisted in measuring the quantity of water evaporated, and weighing the coal burned, during 120 hours of continuous firing, from Monday, March 21st, 1870, at noon, to the following Saturday at noon. It was designed to maintain the firing and pressure of steam uniformly, night and day, throughout the trial, but it was not found to be convenient to maintain the pressure fully during the night; the mean pressure during the day being about 68.60 lbs. above the atmosphere, and during the night about 65.02 lbs. Fire was made up under this boiler early in the morning of Monday, March 21st. The usual custom is to clean out the clinkers from the grate and make up the fire at 11 o'clock, A. M., which gives a fire in its best condition about one hour afterwards. This was done in this trial, and the water brought to the usual height of the 5th gauge cock at noon, when the trial commenced. All the ashes were then removed from the ash pit, and all the coal in the vicinity of this boiler removed from the floor, and the coal weighed out for the trial put in its place. At the end of the trial the firing was done, as nearly as practicable, in the same manner, the fire being left in its best condition, with the usual quantity of coal on the grate, and the water at the 5th cock.

The quantity of water evaporated was measured in a large wooden tank, constructed for the purpose of heating water for use in the Calico Print Works of the establishment, with part of the exhaust steam from the engine. For this purpose it was detached from its usual connections, and connected only with the force pumps supplying this boiler. The contents of the tank for the 5 ft. in depth, gauged by measurement for this purpose, was 3,316.24 cubic ft. This quantity was not all used before refilling. It was filled up 5 times during the trial, or once each day, and the quantity drawn from each filling noted. The whole quantity drawn was 11,405.017 cubic ft., at the mean temperature of 37.97 deg. Fahr., or 711,456.37 lbs.; allowance being made for a small leakage, and for a slight enlargement of the tank when filled, the dimensions having been taken when empty.

The coal used was white ash anthracite, from the Preston and Gilberton mines, taken from a lot of about 14,000 tons received during the year 1869; part of it was exposed to the weather and part of it stored under sheds. It was taken without selection, but I have learned, subsequently to the trial, that about half a ton of slaty lumps was thrown out in the boiler-house, and an equal quantity of purer coal substituted. The coal was weighed on platform scales, 2 tons at a time; the scales having been previously adjusted to weigh accurately, by the official sealer of weights and measures for the city of Lowell.

The total amount of coal weighed out for the trial was		85,120 lbs.
Of this, not put on grate ..	2,076 lbs.	
Cinders picked out from ashes at end of trial, that might have been burned, but could not conveni-		

ently be returned to the grate during the trial.... 1,112.5 "
3188.5 "

Total amount of coal burned ....81931.5 "

The temperature of the feed water was observed in the feed pipe near the force pumps, by a thermometer, the bulb of which was inserted in the pipe and exposed to the current, the scale projecting through a packed joint. The pressure of the steam was observed by an Ashcroft gauge in the steam pipe between the boiler and the 1st valve. The temperature of the steam was observed in the steam pipe, close to the pressure gauge, by means of a thermometer inserted in a tube filled with oil, fitted into the pipe. The temperature of the gases escaping from the boiler was also observed by means of a similar tube, filled with oil, inserted in the sheet-iron flue, about 10 in. from the chamber over the boiler. The temperature of the air in several places was also observed. All the thermometers used have been tested since the trial by Huddleston, the well known thermometer maker, of Boston, and the pressure gauge by the American Steam Gauge Company, of Boston. In the results given the corrections have been applied:

Mean temperature of water in feed pipe (extremes 41.6° and 36.5°..... 37.97°
Mean temperature of steam in steam pipe (extremes 322° and 294°)...... 311.8°
Mean pressure of steam in steam pipe above the atmosphere (extremes 79 lbs. and 45.5 lbs.)................ 66.46 lbs.
Mean temperature of gases in flue (extremes 355° and 208°) .... 286.4°
Mean temperature of air in boiler-room, at thermometer 5 feet above floor (extremes 82.5° and 55°.... ...... 73.4°
Mean temperature of air in boiler-room, at thermometer 40 feet above floor (extremes 130.5° and 107.7°)....... 117.7°
Mean temperature of air out-doors, in shade (extremes 51° and 19°) .... 33.9°
Water evaporated from the initial temperature of 37.97° by each pound of coal $= \frac{711456.37}{81931.5} =$ .... 8.684 lbs.

To reduce this to the evaporation from 212°, I use the formula given by Rankine, at page 254 of his "Manual of the Steam Engine," viz.: $h_{2\cdot1} = 1092 + 0.3\,(T_1 - 32°) - (T_2 - 32°)$. In which, $h_{2\cdot1} =$ the multiplier of the observed weight of water evaporated by each pound of fuel, which, being divided by 966, gives the weight of water which would have been evaporated by each pound of fuel, had the water been both supplied and evaporated at the boiling point corresponding to the mean atmospheric pressure.

$T_1 =$ the temperature of evaporation (see below).............................299.46°
$T_2 =$ the temperature of the feed water = ... 37.97°
Substituting the values for T_1 and T_2 we have $h_{2\cdot1} =$ 1166.27
And the equivalent amount of water, if supplied and evaporated at 212° =
$8.684 \times \frac{1166.27}{966} =$............... 10.484 lbs.

As above described, the boiler is so constructed that the heated gases all pass through the tubes, the upper 3 ft. of their length being above the water line. The exterior of the upper 9 ft. in height of the central cylinder, which is steam space, is also exposed to the heated gases. The effect of this arrangement being, of course, to superheat the steam.

The observed mean pressure of the steam, per square inch, above the atmosphere, was.................. 66.46 lbs.
The temperature of saturated steam, of this pressure, according to Regnalt, as given in the table in the "Description of Richards' Improved Steam Engine Indicator," by Chas. T. Porter, London, 1868, is ....299.46°
Mean observed temperature of the steam...............................311.80°

Excess of the observed temperature, being the amount the steam is superheated .... 12.34°

The superheating being part of the useful effect of the fuel, its equivalent in evaporation of water should be added to the results obtained above.

The specific heat of steam being, according to Rankine, 0.475, that of water being 1. The equivalent evaporation of water from the initial temperature, due to the superheating is $\frac{0.475 \times 8.684 \times 12.34}{1166.27} =$.... 0.044 lbs.
Which added to 8.684 lbs., gives for the equivalent evaporation from the initial temperature .... 8.728 lbs.
The equivalent evaporation from 212°, due to the superheating, is $\frac{0.475 + 10.484 \times 12.34}{966} =$........ 0.064 lbs.
Which, added to 10.484 lbs., gives for the equivalent evaporation from 212° .... 10.548 lbs.

When in ordinary use, the temperature of the feed water is sensibly raised by pas-

sing through the tank over the boilers; this is, of course, part of the duty of the boiler, and its equivalent in evaporation should be added to the above in order to give the total evaporative power of the boiler. In this trial the feed water was not so heated, and I have no means of ascertaining to what extent it would have been heated if it had passed through the tank in the usual manner; I therefore do not attempt to allow for it.

The amount of clinkers was..........	3261.0 lbs.
" " ashes "	1322.5 "
Amount of clinkers and ashes not returned to the fire..................	4583.5 "

Or about $5\frac{1}{2}$ per cent. of the coal burned.

COLD BLAST, WARM BLAST, HOT BLAST.

Correspondent Lake Superior "Mining Journal."

The last two are relative terms; and, considering that the natural temperature of the air varies from 100 deg. above to one-half as many deg. below zero, in this latitude, strictly speaking, all are relative terms. In the iron trade of this country, however, a blast heated up to not exceeding 450 deg. Fahrenheit is said to be warm; from that up to the melting of lead, and somewhat above, has been called hot blast. But of late some of our furnaces reach 900 deg., and in England 1,200 deg. is said to have been attained. If we retain the nomenclature which forms our heading, a new term will have to be added—we suggest red-hot blast. And this is the literal fact: air and all other substances begin to show a dull red at between 900 deg. and 1,000 deg. Furnaces are now running in Pennsylvania where the goose-neck pipes are so hot as to light up the tuyere arches at night.

One advantage of heating the blast is very apparent; cast-iron melts at about 2,800 Fahr. Now, all air going through the furnace must be raised to this temperature. If we put the air into the furnace at 400 deg., we evidently save one-seventh of the fuel required to heat the air; a very important item when we consider that it takes about 10 tons of air to produce 1 ton of iron.

But this is not the whole, nor even the greatest advantage, as all know who have made hot and cold blast iron in the same furnace, for experience shows that the saving of fuel is from 20 to 50 per cent., in using hot against cold blast, and the make increased in a still greater proportion. This is due to the increased chemical affinity found to exist between heated air and coal. Combustion takes place more rapidly, hence is more intense and concentrated. No more units of heat are evolved, but the combustion is confined to the more immediate vicinity of the tuyeres. It is well known that cold-blast furnaces are hotter in the upper parts than hot-blast furnaces, while in the latter the zones of reduction and melting are lower down in the furnace. The gases raising from this deep-seated region of greatest heat give out their caloric to the descending stock, thus thoroughly preparing it, and finally leave the furnace mouth at a lower temperature than those of cold-blast furnaces.

The reason of the increased intensity of combustion due to heated air has been explained by supposing the rarefied oxygen to more easily permeate the pores and interstices of the fuel, thereby increasing the surface exposed to the oxidizing influence. Whatever the explanation, the fact is established that hot blast produces iron faster in any given furnace, and with less fuel than cold blast. No limit has yet been found. Theoretically there must be carbon enough to act as a reducing agent; but practically the amount of heat that can be employed seems likely to be limited by the difficulty of keeping joints tight and working about highly heated pipes.

As to its effect on the quality of the iron produced, there has been much discussion. When we consider that within the experience of many of our older iron masters, all the iron made in the world was cold blast, and that now it is nearly all hot, we need have no serious apprehensions as to the future of the hot-blast metal. Producers and consumers of cold-blast iron who had made money in the trade, were naturally opposed to any change which looked to a rebuilding of their furnaces and a revising of their traditions.

Iron workers are conservative. Again

there is a universal belief among men that what costs the greatest amount of time, material, and money to produce must be the best (and it is not a bad general rule), hence that this cheaply-produced, new-fangled pig metal was of an inferior quality. Again the hot-blast men soon found that they could produce good metal from sulphurous and other inferior ores that had before been considered worthless. This was bringing "good out of Nazareth," and was against them. But time has changed all this; it would not now be possible to make all the iron consumed in the world if done by cold blast. English hot-blast mineral fuel iron is now put to some of the most trying and important uses, for which a short time ago only cold-blast charcoal iron was deemed fit.

But there is often a difference between cold and hot-blast iron, and it is not improbable that some ores may produce a better iron worked cold than hot, in the present state of iron metallurgy.

Intense heat in the furnace tends to reduce the silica and leave its metal silicon in the pig, where it is objectionable for some uses, particularly for bar iron. This can generally be corrected by using a larger amount of lime, which, uniting with the silica, carries it off in the slag. It would be well for furnace men proposing to raise the temperature of their blast, to bear this in mind.

To illustrate and apply these suggestions in Lake Superior practice, let us look for a moment at the Deer Lake Furnace.

The stack is 33 ft. high, 7 ft. 8 in. bosh, hence probably the smallest furnace built in the United States within five years, and in this particular a grave mistake. The furnace runs but six days in a week, banking up Saturday night at 12 o'clock, and starting again the following midnight. This practice we believe to be a mistake, not only from the money-making standpoint, but on true moral and religious grounds; but it is neither to the size of the furnace nor to its religion we desire to call attention here, but to *its enormous hot-blast oven*, and the remarkable results it is producing.

This oven, arranged on Player's plan, contains 45 tons of metal, which is 50 per cent. more than found at our largest charcoal furnaces having twice the capacity of the Deer Lake stack. The furnace is driven by water, hence all the gas is available for heating the blast, and being all collected by the cone and thimble arrangement, is burned in the great oven which heats the blast near to red hot. Messrs. Ward & Hall have no means of measuring the temperature; they only know that it is a great deal hotter than the melting of lead.

As to results: the furnace has averaged 11 tons per day for three weeks on 110 bushels of coal per ton, one-half of which was soft coal, mostly pine tops. New York Company's hard ore only was used, averaging 66 per cent.

We know that somewhat better work has been done, but considering the great disparity in the size of the furnaces, and the inferior quality of the fuel used at Deer Lake, and the weekly stoppages, this is extraordinary work.

We also know that the concern is very well managed, but believe that the above record is chiefly due to a very large hot-blast oven, and to the fact that all the gas is available for heating the blast.

Application: Proprietors and managers of hot-blast water furnaces, running on L. S. ores, had best follow the lead of the Deer Lake—tear down their ovens and build larger. The thanks of the charcoal ironmakers of this region are due to Mr. Ward for having pioneered *red-hot blast* into Lake Superior practice.

If any furnace man wishes to know about how much money it is costing him to support the magnificent flame out of the mouth of his furnace, let him build a fire of corresponding size on the fill plate, feeding it with charcoal at 13 cents per bushel (stumpage and kiln rent in); he will know at the end of a month what it costs to be a "fire worshipper."

M. Riche, in his researches on alloys, finds that tom-toms and cymbals are made of bronze that can be worked cold the same as iron or aluminium bronze. The best tone is produced by an alloy composed of 78 parts of copper and 22 parts of tin.

Iridium, used as a coloring matter for glass and porcelain, gives a tint of intense blackness.

THE STRUCTURAL UTILITY OF IRON.

From "The Builder."

Recent incidents cannot fail to awaken a certain degree of interest in architectural and engineering circles, apart from that which is associated with the fracture of the Holborn Viaduct columns. In accordance with the conclusions of those whose opinion in such matters is regarded as deserving every attention, it would appear that the perishable nature and properties of iron as employed in static engineering no longer forms the principal object to be considered in reference to its utility or value as a building material. The decay to which iron is exposed from atmospheric changes and by variations of temperature has long been within the knowledge of many, and more recently the transitional qualities which iron and steel have been observed to possess, have attracted more general recognition. The molecular aggregation and dissociation of iron have been demonstrated to such a point of clearness that the material may be said to be capable of being held in atmospheric tension more eminently, perhaps, than any other substance employed in building. In addition to this circumstance, the molecular capacity of iron is known to be such as to admit of essential changes of its properties and functions. The same bar of material would, in accordance with the varying conditions of its employment, exhibit all the features and elements of new and distinct substances. The freedom of motion to which the constituent elements of iron and steel are known to be susceptible admits of the presentation of various orders or classes of fracture in the same sample, and the nature of such fractures may be said to determine the practical limits of the adaptation of iron as one among the materials of construction.

The sudden fracture of railway-carriage axles is sometimes attributed to a change effected in the material by vibration. After subjection to vibratory tests, a bar of fibrous iron has been observed to have completely changed, presenting a granular or crystalline fracture, it may be ; and it is eqally possible that a crystalline or granular sample should, under certain conditions, acquire the properties and features of a fibrous specimen. The singular atrophy, or withering away, to which iron, under some circumstances, is liable, and of which a familiar instance may have been noted on the part of many at the base as well as in other parts of iron railings, may readily suggest itself. Although an incident probably in a measure now obviated, and comparatively of but little moment, such exhibitions, notwithstanding that they may be said to be capable of being effectually remedied, invite special observation on the part of those who may be led to widely adopt the employment of iron in construction.

It might be unavailing, if not altogether devoid of interest, to single out the more trivial and fortuitous examples of the speedy decay to which the material under consideration is occasionally seen to arrive, but the total and intrinsic degeneration of such a substance by its mere proximity to others, whatever the process through which such a result is reached, is a subject possessed of unequivocal claims to investigation. In alluding thus prominently, it may be viewed by some, to what may be open to be regarded as the more unfavorable elements of this question, we would be understood as far from discountenancing the application of iron in a constructive direction. Many circumstances, however, we incline to think it would be agreed, contribute to indicate the necessity of some selection as to those conditions under which its employment would become more appropriate and effectual.

Upon the completion of many important erections in which iron is seen to have been largely employed, it is by no means an infrequent occurrence to observe that opinions are in certain directions at once set in motion, to the detriment of the undertaking in many instances, it may be gratuitously, but in the general result uniting to diminish the assurance of the public with reference to the stability or safety of such structures.

It has upon some occasions unhappily proved too well founded that substantial grounds may have existed for some amongst the numerous deductions to which these speculations are likely to lead, while in other instances the conclusions

which have been derived have been altogether disproved or shown to have been unfairly or unduly exaggerated.

It is a matter confessedly of such difficulty, even in the engineering circles, to assume an unconditional responsibility with reference to some of the reputed properties of iron, that a tendency has declared itself on the part of those more intimately interested in that science in connection with which its structural use is so closely associated, to endeavor to discover continually improving and more favorable modes of its application.

It is this latter view of the subject probably which may be considered to possess more special claims to the notice of our readers, nor should it be omitted to be conceded that in entering into a more critical examination of what few would probably treat as altogether unimportant, the modest pretensions which have been put forward on the part of the engineering profession are calculated to invite considerable forbearance, and may happily induce the supposition that the authority which age and experience can alone impart to the principles of any art or science may be expected to operate in its favor as it has done in many analogous instances.

Perhaps the most complete and authoritative inquiry which has yet been made with reference to the utility of iron for purposes of construction, is that which was instituted some twenty years ago before the committee for inquiring into the application of iron to railways. Since the time at which those investigations were conducted, the theory of the structural utility of iron has sought to embrace such conditions, and the process of the manufacture of that material have undergone such modifications, that in the future interests of architectural, no less than engineering science, it would appear far from undesirable that some similar inquiry should now be established.

The important experiments upon the properties of iron and steel which we owe to Mr. Kirkaldy, and to which we had occasion to allude in a notice of Mr. Bindon Stoney's lately-issued work "On the Theory of Strains in Girders and similar Structures," would almost of themselves suggest the wisdom of further legislative inquiry; for while manufacturers and public alike may appeal, in a certain measure, to the results of such experiments as likely to exercise a salutary check over the constructive application of the materials in question, it is the result of a purely voluntary and promiscuous system.

It may be fairly questionable whether the subjection, say, of the whole series of links of a suspension bridge to a fixed and arbitrary strain, is calculated to enhance the stability of such structures when erected.

Mr. Stoney, in stating that the functions and properties of iron become changed after its subjection to various strains, has recorded what has long been known perhaps in a less determinate form. Whatever may chance to constitute those obscurer qualities in iron and steel to which attention is attracted upon the occurrence of unexpected ruptures or disasters through the employment of those materials, it is obvious that they appear calculated to afford important constructive facilities, and will always invite employment in some building capacity. It is of practical moment, therefore, to the architect to seek to bring under more critical examination the occasions of failure in either of those materials in their structural application. The fall of the Manchester Station roof, some two or three years ago, it may be remembered, was attributed to a flaw in some portion of the casting; while the more recent instance of the Caledonian Station has been laid to the account of a tie-bar giving way; and in the case of the Ludgate-hill Station, the accident was referred to the simple misplacement of a strut.

It is with no intention of imparting an undue importance to such incidents that we make reference to occurrences some two or three years old; but the integrity of an extensive undertaking, it may be in iron, has been so frequently traced to, and imperilled by, the giving way of some trivial support, or member of the general structure, that the circumstances may demand pointed observation in any further inquiries into the strength and adaptation of such materials. In reference to novel discoveries in static engineering and attempted improvements in the application of the materials with which that science is identified, it cannot but afford matter of congratulation to notice any instances where it may have been more clearly shown that undoubtedly successful results have been attained.

Although the extraneous successes of certain engineering experiments may be said to possess less interest in architectural circles than where it has been sought to import similar endeavors into the domain of architecture, it must necessarily be of interest to note those claims which are occasionally alleged upon special grounds, with reference to the allied arts of construction. Apart from the employment of iron, so obviously has the theory of engineering been necessarily founded upon certain of the principles of architecture, that a sense of usurpation reigns in engineering circles wherever the distinctive element is more notably absent; and this it is which, in the opinion of some, might be held to shed light upon the assertion of an eminent member of the profession, that it has been very unsatisfactory to attempt to describe in a few general words what a civil engineer really is.

As an illustration of the more unfixed elements upon which the art of construction in iron is yet based, reference might be made to the evidence which was given by Mr. Robert Stephenson before the Committee of Inquiry, upon the application of iron to railway structures. The report of this Commission is known to be still regarded as of high authority in engineering practice, and the circumstance may be noted with all the more pleasure, as instancing the undoubted progress which has been made since the time of the inquiry in the profession to which it relates.

Upon being asked as to his opinion with regard to suspension-bridges, and whether he considered them at all applicable to railways, Mr. Stephenson replied: "To a very small extent. I do not think, with the prospect of our weights increasing upon railways, that you can run a locomotive over any chain-bridge in existence."

We have already had occasion to advert to the opinions which have been derived by Mr. Edwin Clark as to the construction of suspension-bridges, wherein he expresses his belief that the erection of a suspension-bridge sufficiently rigid for the purposes of locomotive traffic would be tantamount to the construction of a tube. Mr. Peter Barlow, whose experience in the structural application of iron entitles his opinion to great weight, is at issue with Mr. Clark, and remarks that, "although unsupported by fact or experiment, Mr. Edwin Clark's theory has been received and acted upon, not only by a large portion of the public, whose impressions of suspension-bridges are derived from what had hitherto been constructed of insufficient strength and without being combined with a girder, but it it had been received and acted upon by engineers of eminence in this country."

In the inquiry before the Commission to which we have alluded, an important exception was taken by Mr. Stephenson in favor of a system of suspension-bridge which at that time attracted considerable notice. The discovery invited such attention that Lord Western was induced to communicate at great length with Viscount Melbourne as to the superior applicability of the system to the repair or renewal of the Menai Bridge, deducing from actual experiments its merits in bridges of large span. This class of structure is known as Dredge's Patent Taper Suspension Bridge. Lord Western observed that the inventor insisted on the possibility of reconstructing the ironwork of the Menai Bridge at a less sum than the superfluous iron would sell for, pledging himself to the power of the bridge if the irons were altogether altered, using Lord Western's words, and reconstructed on his principle, to be capable of supporting on transit 1,000 tons.

The main principles of the Dredge suspension-bridge would seem to be comprised in the employment of pyramidal suspension-chains, and the substitution of oblique for vertical rods for connecting the suspension-chains with the roadway. The invention of Mr. Dredge, with reference to the application of iron in the erection of bridges more particularly, was supposed to embody such important structural principles, that, apart from the exception which was made in its favor before the Commission to which we have referred, it may now upon various grounds be found to possess further claims to practical consideration.

The Dredge principle is stated to have been founded upon the view that bridges are only brackets, and should be dependent upon their bases or abutments, and the strength of the material of which they are constructed, like the human arm, which depends on the shoulders, and not

on the fingers' ends—or the limb of the oak, which is sustained by the larger part of the branch that grows from the tree, and not by the ends of the twigs at its farthest projection. Bridges have hitherto been made to rest on their centres, as beams in architecture, and hence the superfluous material in them, with the immense accumulation of leverage that exists on their centres, is the cause of their undulation and destruction. In a common bridge, whose depth is one-twentieth of its length, and the weight 1,000 tons, the central forces are computed at 5,000 tons, instead of which no description of force or weight, according to the Dredge principle, should exist on the centre of the arch of any bridge, for it is but the extremity of two projections. The operation of the system is therefore in the direction of the annihilation of these static forces, which of themselves tend to destroy the structure, and to counteract which an excessive quantity of material must necessarily be employed, in accordance with more usual practices. One of the more important elements in connection with the erection of all suspension structures of the nature in view, has been the acquisition, at the least cost, of the maximum rigidity. and to accomplish this, various experiments have been suggested and employed. In the original suspension-bridge which existed at Hungerford Pier, in the line of the present Charing-cross railway, the lateral motion, as well as the deflection of that structure under passing and unequal loads was remarkable. In that case, as in the present Hammersmith and Chelsea bridges, the roadway was attached to supporting chains by vertical rods; but in the substitution of oblique bars in the Dredge system, considerable rigidity was supposed to have resulted. A more special treatment of this element of bridge construction may be noted in Koch's system of suspension, a class of structure perhaps deserving of fuller notice than it has yet received; but the more conspicuous instance is that to be observed in the stiffening which has been imparted to the Niagara Railway Bridge, by means of timber trussing following up the direction of the chains. This feature has been reproduced in Lambeth Bridge, iron being there, however, substituted by Mr. Barlow for the timber, as employed in the Roebling system. In most of the instances which we call to mind, the metallic section of the supporting-chains has been uniform at any point along the span, nor do we remember any case of such singular deviation from this principle as that to be noted in the pyramidal chain-bridge. The attempted economy of material towards the centre of lattice girder bridges may faintly shadow out the principle involved, and we cannot resist the impression that an exaggerated view has been taken as to the possible saving of material as between the Dredge principle of suspension and others. Perhaps the most exquisite adaptation of iron to structural purposes—that is, in a useful sense—to which we may refer, is instanced in the case of the London, Chatham, and Dover Railway Bridge, erected at the crossing of the Thames at Blackfriars; but it seems unhappily possessed of fewer lasting elements than its present neighboring structures.

The results of the experiments which were communicated by Lord Western to Lord Melbourne, upon the distinctive features of the Dredge bridge, would appear well calculated to attract the attention of the scientific; but, as we have before had occasion to notice, the extreme divergence of views entertained by the more eminent professors of engineering detracts from the value or importance, in a measure, of individual conclusions. Whether greater triumphs may be derived from the application of wire cables, assisted by vertical and horizontal trussing by the system of pyramidal chains and oblique suspension-bars, or by the tubular system conjoined with chains, or in the form of tunnels, we would be indisposed at this moment to venture to predict; meanwhile attention is being attracted to more recent discoveries as to the structural application of iron and steel. Out of the mass of conflicting and antagonistic evidence with which the theory of engineering is obviously beset, it would afford matter of congratulation should some settled principles be evolved, and it is because we incline to the view that at length some tendency in this direction may be detected, that we would seek to bring under notice some few of the more striking features of that art.

KANSAS has now more than 2,000 miles of railway.

ON SOME RECENT IMPROVEMENTS IN PISTONS.

From "The Engineer."

In pistons of many descriptions at present in extensive use, metallic or other packing is employed, and frequently in such manner as often to require adjustment by screws or other means provided for that purpose, which adjustment, besides requiring great skill and extreme care, must be always more or less uncertain, and consequently unsatisfactory, as the workman performing the operation under ordinary circumstances has no reliaable indication of the extent of compression of the packing. The result often is that pistons are at first starting, so tightly packed as to cause great waste of power by friction, besides occasioning rapid wear of the piston and cylinder, so that leakage quickly follows, thereby necessitating the repacking of the piston at frequent intervals, an operation which usually involves considerable expense and loss of time.

Another description of packing in very common use is the ordinary plain cast-iron ring, which is likewise open to the objection that on being first put in, it presses to a greater extent against the cylinder's surface than is the case after working for some little time, besides which, its pressure does not vary in proportion to that of the steam upon the piston's side ; consequently there is great loss by friction at first, and subsequently by leakage arising from excessive wear.

Now Messrs. Quick and Sampson obviate these serious evils by the employment of a novel and simple method, invented by them for causing the ring or rings of the piston to press constantly against the inner surface of the cylinder with a force which shall vary in proportion to the extent of variation between the pressures on the respective sides of the picton, the packing being so adjusted as to form a good but not unnecessarily tight joint at a minimum pressure, to force the piston ring or rings more and more tightly against the inner surface of the cylinder as the pressure upon the side of the piston increases, and to correspondingly reduce the force with which the ring or rings so presses or press against the cylinder in proportion as the pressure against the piston's side diminishes ; and they attain these results without the direct action of the steam or other actuating fluid behind the packing rings. For these purposes the block or body of the piston is formed with small holes or passages, the number of which may be varied to suit the size of the piston, and these small holes or passages are fitted with corresponding small pistons properly packed and capable of moving therein when influenced by any excess of pressure at one side of the piston over that at the other side. The apparatus is so arranged that in the normal position of these small pistons—that is, when there is an equal pressure on both sides of the main piston—the latter will lie or move perfectly easy within the cylinder, but that any change in pressure on the respective sides of the piston will cause the small pistons to move endwise within their respective holes or passages in the block or body of the main piston, and such movement of the small pistons will be communicated from them through the cap, top plate, or junk ring of the main piston, or through suitable L pieces or equivalent devices, to the packing ring or rings, so as to force the latter against the inner surface of the cylinder.

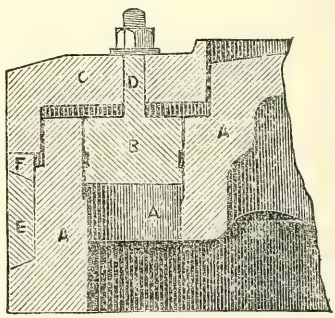


Fig. 1.

Fig. 1 represents a tranverse section, and Fig. 2 a plan (to a reduced scale) of part of a 55 in. piston which has been working constantly for upwards of twelve months in a single-acting pumping engine at the Southwark and Vauxhall Waterworks at Battersea.

A is the block or body of the piston ; it is formed with three holes or passages A^1, provided with small pistons B, $3\frac{1}{2}$ in. in diameter, which work therein, and are

made to fit accurately by means of packing springs. The pistons B are connected to the junk ring C by small stems D, and nuts, as shown; E is the packing ring, whose edges are bevelled, and F is an intermediate ring having only its lower edge bevelled.

The bevelled surfaces of the rings E and F and lower part of the packing recess are ground so as to fit one another accurately. Any excess of pressure on the upper side of the piston has the effect of causing the junk ring C to press against the intermediate ring F, thereby forcing the bevelled packing ring E against the inner surface of the cylinder by compressing it between the bevelled surfaces of the block A and intermediate ring F.

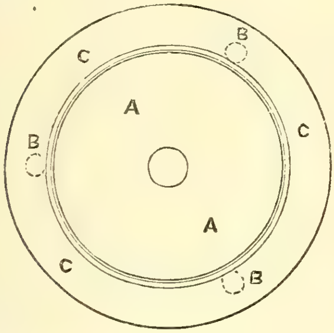


Fig. 2.

The piston previously used in this engine had a cast-iron ring packed up by india-rubber interposed between itself and the block of the piston, the india-rubber being compressed by the junk or cap ring. The result of the application of the improved piston in this case has been a reduction in friction during the down stroke equivalent to a steam pressure of one pound per square inch; while the relief afforded to the piston during the up stroke has resulted in an absolute gain of 10 ft. in the height to which the water is raised.

The old piston had to be looked at and repacked two or three times a year, and required a considerable quantity of grease, whereas the new one, after having run for upwards of twelve months without being inspected, was found to be in a very satisfactory condition, besides which the use of grease has been entirely discontinued. Fig. 3 represents part of a 70 in. piston applied to a direct-acting pumping engine at the Grand Junction Waterworks, Kew, working at an average steam pressure of 20 lbs. per square inch. This arrangement may also be applied with great advantage to double-acting condensing pumping or marine engines. A is the block of the piston, it is formed with four holes to receive four small pistons B, each 4 in. in diameter, which are connected by stems D, and nuts, to the junk ring C, as shown. The block A is furthermore formed to receive L pieces

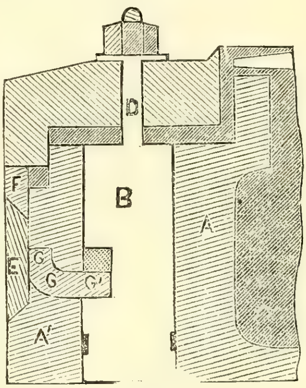


Fig. 3.

G, whose ends G^1 take in recesses formed in the sides of the small pistons B. When the pressure of the steam is on the under side, the small pistons B act against the ends G^1 of the L pieces, and cause their edges G to describe the arc of a circle, and so to force the packing ring E against the interior of the cylinder; but when (in double-acting engines) the steam pressure is against the upper part of the piston, then the junk ring C presses against the intermediate ring F, so that the bevelled packing ring E is forced against the interior of the cylinder by being compressed between the bevelled surfaces of the block A and intermediate ring F.

The following report, dated Feb. 12th, 1870, is from Mr. Alexander Fraser, engineer to the Grand Junction Waterworks. He says:—

"With respect to the patent piston which we have had fitted to the 70 in. direct-acting engine at our Kew Works, I am happy to say that it is a decided success. Since its introduction we have been able to dispense with a ton weight on the loaded plunger, showing a reduction in friction of over 5 per cent.; and whereas the former packed piston required 4 lbs. to 5 lbs. of tallow per day, the new piston requires almost none at all. There is a saving on this head of

quite £30 per annum, besides other advantages due to the absence of tallow in the cylinder. I shall certainly advocate the introduction of the new piston in the other engines at our different works, as opportunities occur for removing the present pistons."

A piston of the same construction as that referred to in Mr. Fraser's report has just been supplied to the Portsmouth Waterworks Company for a double-acting engine. Fig. 4 represents to a larger scale

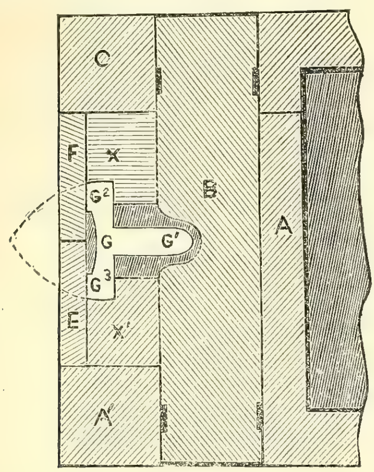


FIG. 4.

part of one of the improved pistons of 10 in. in diameter as applied with very satisfactory results to high-pressure double-acting engines at the Southwark and Vauxhall Waterworks, Battersea, and elsewhere. This arrangement of piston is suitable also for locomotives and other classes of high-pressure double-acting engines. A is the block or body of the piston; it is made with three holes or passages fitted with corresponding pistons B, each $1\frac{1}{2}$ in. in diameter. These pistons pass through suitable holes formed for that purpose in the cap-ring C, which is in this case fixed to the block or body A of the piston by means of bolts; F and E are the packing rings. They are kept pressed against the interior of the cylinder by means of the T pieces G which are fitted into the block A; the ends G^1 of these T pieces pass through holes in the block A, and are let into recesses in the sides of the small pistons B. These recesses are of sufficient size to allow for the necessary motion of the T pieces when actuated by the movement of the small pistons, and for the same reason the edges G^2, G^3 of the T pieces are slightly bevelled. It will be evident that when the pressure of the steam is on the upper side the small pistons act against the ends G^1 of the T pieces, and cause their edges G^3 to describe the arc of a circle whose centre is at X, as shown dotted, and thus to force the lower packing ring E against the interior of the cylinder; and that when the pressure is on the under side the edges G^2 of the T pieces are caused in like manner to describe the arc of a circle having its centre at X^1, so as in turn to force the upper packing ring F against the interior of the cylinder to form the joint.

In a report referring to one of these pistons, Mr. Anderson of the eminent firm of Easton, Amos & Anderson, says:—"The patent piston has been in our foundry engine for a fortnight now, and to-day I had the cover taken off the cylinder and examined it. The engine is horizontal, and runs from 120 to 150 revolutions per minute under 50 lbs. steam. I had the flywheel scotched, and turned the steam full on the piston on the side opposite that from which the cover was removed. I found the cylinder very nicely polished, no trace of scoring anywhere, and the quantity of steam passing very insignificant considering the fact that the cylinder had run four or five years with another piston and had worn oval in the middle.

At the Battersea works of the Southwark and Vauxhall Waterworks Company a piston similar to that referred to in Mr. Anderson's report has been in constant use for about nine months.

During that time it has been examined twice, and was on both occasions found to be in first-rate order. It was put in to supersede a piston with a metallic ring, kept up by metallic springs, which, however, were a source of constant trouble and expense. It may not be out of place here to remark that the duty required to be done by the engines at such establishments as the Battersea Waterworks is of a character which imperatively demands the utmost regularity of action, and therefore that any appliance which is found to satisfactorily fulfil the requirements of such a situation (as Messrs. Quick and Sampson's piston has done) must, as a natural consequence, be one upon whose actual performance of its duty the most complete reliance can be placed.

THE FORECASTING OF STORMS.

Extract from an article by L. A. ROBERTS in the "Western Monthly."

It cannot be denied, that the complicated and constantly varying phenomena of that fickle entity which we denominate the Weather form a problem which in the nature of things must be extremely difficult of solution; and it is hardly probable that any man will ever be able in this field of inquiry to reach the same satisfactory results that have rewarded the labors of the astronomer. It is a source of legitimate pride to Americans, however, that in two important departments of meteorological investigation citizens of this country hold the first rank. To Dr. Franklin belongs the honor of discovering and elucidating the principles of electricity, and of demonstrating the influence of that subtle force upon the earth and its atmosphere; and it was Redfield who, something like a century later, deduced from his own careful observations of storms upon our Atlantic coast the important generalization that there is a class of great storms which originate near the equator, in the region of the West Indies, and rapidly advance, according to a fixed law, with a simultaneously gyratory and progressive motion, upon a well-defined curved axis toward the north pole. These storms vary greatly in intensity and in breadth—sometimes being confined to a narrow belt upon or a little way off from the coast, and again extending over a wide expanse of land and sea; but that they uniformly follow the same general course indicated by Redfield has been abundantly established by a great number of subsequent observations. It is not designed here to enter into an elucidation of this important law, but attention is called to it as marking one of the few real and tangible and practical achievements in the field of meteorological science. Its discovery and announcement stimulated investigators both here and in the Old World to renewed energy in their efforts to unravel the mysteries of atmospheric phenomena. The subject of storms, both ocean and inland, was especially studied with quickened zeal and enthusiasm; and in due course of time an attempt was made abroad—first in England, then in France, and afterward in other continental countries—to utilize the knowledge gained thereby in the interests of commerce, which, ever since it has existed, has been subjected to constant peril and loss from the effects of storms. The prevailing courses of the most destructive storms in various localities having been definitely ascertained, measures have been taken to give warning to exposed points of their approach, by means of the telegraph. This intelligence being promptly communicated by preconcerted signals to all vessels passing within sight of the shore or lying at anchor in harbor or roadstead, such vessels are enabled to take all necessary precautions against disaster before the storm shall burst upon them; and immense damage to shipping has thus in very many instances been avoided.

Notwithstanding the salutary operation of this system abroad, however, and notwithstanding the peril from storms to which our commerce on the great lakes and the Atlantic seaboard is constantly exposed, no measures have been taken in this country, until within the past few months, for the inauguration of such a system here. Early in the present session of Congress, however, the matter was brought to the attention of the House of Representatives by Hon. Halbert E. Paine, of Wisconsin, who offered in that body a joint resolution providing "for taking meteorological observations at the military stations and other points in the interior of the continent, and for giving notice on the northern lakes and seaboard of the approach and force of storms." The resolution in full is as follows:

"*Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled*, That the Secretary of War be, and he hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the sea-coast, by magnetic telegraph and marine signals, of the approach and force of storms."

This resolution was promptly passed by both houses of Congress, and on the 9th of February, 1870, became a law by

the approval of the President. By General Orders No. 29 from the headquarters of the army, dated March 15, 1870, the chief signal officer of the army, Brevet Brigadier-General A. J. Myer, is charged, subject to the direction of the Secretary of War, with the execution of the provisions of this enactment, and all commanding officers are enjoined to afford every facility for the successful prosecution of the undertaking ; while scientific establishments, commercial associations, and others, are requested to aid, by their co-operation, in the accomplishment of the work.

Professor J. A. Lapham, of Milwaukee, impressed by the frightful aggregate of a single year's disasters to vessels on the great lakes—amounting for the year 1869 to the immense number of 1,914, with an estimated damage to property of over four millions of dollars—was perhaps the first to suggest some action by Government for inaugurating such a system of storm-reporting as, through the efforts of General Paine, has now happily been adopted. It should be remarked that by no means all of the disasters included in the aggregate above given were of that class which might have been obviated by the operation of the system we are considering. Very many were due to imperfect machinery, defective boilers, careless collisions, conflagrations, and other causes. Yet, making all proper deductions on this score, enough remain to be attributed to the destructive force of severe and unheralded storms, to fully justify any action by Government looking to a mitigation of the destruction of property and the peril and often loss of life which they entail. No corresponding statistics are at hand as to the yearly disasters upon our Atlantic seaboard ; but these are very numerous, as is well known, and of these a much larger proportion than of the lake disasters are attributable to the agency of storms. Besides the great equatorial storms already alluded to, which in their course toward the pole follow approximately the coast line of the United States, our coasting vessels are likewise exposed to frequently-recurring tempests, especially in the summer season, which originate probably upon the great desert basin in the interior of the continent, and, sweeping eastwardly across the Mississippi Valley and the great lakes, expend their final fury upon the ocean and its navigators.

Nor must we overlook the damage often worked on land, as well as upon the water, by these latter storms, and by those tornadoes of narrower limit and shorter duration, but often of even greater intensity, which prevail at intervals throughout the Mississippi Valley and lay waste the narrow belt of country which they traverse. Of this class was a storm which swept through Northern Ohio and on the Alleghany Mountains in Pennsylvania in the summer of 1855, demolishing very many buildings in its course, uprooting trees and razing fences, and causing the death of many persons. So furious was this storm, and yet of so limited a breadth—only about an eighth of a mile—that while in some villages over which it passed scarcely a house escaped damage, in others only the northern or southern section of the town would be devastated ; the outer verge of the destructive force being so sharply defined that while one house, that fell within its track, would be almost totally destroyed, another, but a few yards distant, would be wholly unharmed. The course of this storm may even yet be easily traced in the forests through which it raged. It cut a clean swath as it went, leaving openings that look as if they had been cleared for a highway or a railroad. The timber thus prostrated was in some cases utilized for firewood or for lumber ; but in many places the trunks of the trees were left in such inextricable confusion and tangle—having fallen in every conceivable direction, and being in some instances individually twisted into splinters, as a result of the rotary action of the storm—that it was found inexpedient, in a country where timber was plenty, to attempt to "pick up the pieces ;" and thus the logs were left to rot and replenish the earth. And now, throughout these storm-openings in the woods, vast thickets of the highbush blackberry have grown up ; and so we have, as the latest result of that furious tempest, an almost unlimited abundance yearly of the finest blackberries anywhere to be found.

No one who has witnessed such a storm as this will ever forget it. The imminent peril of a storm at sea may be greater and more appalling ; but nothing can be more exciting than one of these fierce whirling tornadoes, accompanied,

as they almost always are, by a deluge of rain and an almost constant rolling of thunder and glare of lightning. The storm is heralded by a heavy mass of cloud in the west or southwest, dark, with a sulphurous tinge, over the face of which there is an almost constant play of lightning, and within which an ominous muttering of thunder. Then there is a dash of rain, a moaning of the wind, and the next moment the storm bursts upon you. Then the air is full of a tumult of unwonted sounds. Loose shutters, sign-boards, and what not, are dashed against the house. Chimneys are blown into individual bricks, and the bricks come clattering down the flues. Doors and windows are burst open; the house shudders to its foundations; and the next moment you behold your roof following your neighbor's in a wild flight for the open country—going to pieces as it is borne along like a wreck upon the sea—scattering its fragments broadcast, some of them being found afterwards miles away. Such unfortunate persons as chance to be abroad upon the streets when the fury of the tempest is let loose, strive in vain to make headway either with or against the current, and can do no better when blown to the ground than lie prone there and thank their stars if nothing more pitiless than the drenching rain shall fall upon them ; for factory chimneys and church spires go down like grass before the mower, and walls are falling on all hands. One poor man, seeking to rescue a span of valuable horses that are hitched to leeward of a house wall that he fears may fall, is too late ; for even while he is in the act of untying the halter the wall is down, crushing the horses and burying himself to the middle in its *debris*,—and there he stands, upright, stark dead in an instant! A little farther down the street an unfinished frame building goes down even before the workmen upon it can reach the ground, and three men are crushed in the mass of timbers and escape death by a miracle.

All this, and vastly more, in one little village ; and a dozen villages are in the track of the monster. Aye, a monster he is, and almost insatiable, but not quite ; for right in his course stands a little country-house, the inmates of which, looking westward, hear his roar and see him come crashing through a belt of woods a quarter of a mile away. They make such hasty preparations as they can for the impending catastrophe ; but, to their utter astonishment, they find in a minute or so that the storm has passed them by unharmed and is tearing through the woods to the east of them. This characteristic of these tempests has been often observed. While in general they move upon the ground, sweeping it clean as they go, occasionally they rise above it, and again descend—bounding, as it were, like an india-rubber ball that has received a superior ground stroke from the champion batter of a "first-nine."

Perhaps the most terrible storm of this character that ever occurred in the United States was that which destroyed the villages of Comanche, Iowa, and Albany, Illinois, situated upon opposite sides of the Mississippi, on the evening of June 3d, 1860. This fearful storm will long be remembered by all persons who resided at the time of its occurrence anywhere in the region through which it passed. It commenced as two separate and distinct tornadoes, which, moving eastwardly in well-defined and nearly parallel courses, crossed Cedar River in Iowa 12 miles apart, and then gradually converged, until, at a point about 25 miles west of the Mississippi, they united, and thence advanced in a single column with indescribable fury. After crossing the Mississippi, the force of the storm gradually diminished, and it had subsided into a mild gale by the time it reached Lake Michigan. In this tornado one hundred and thirty-four lives were reported to have been lost west of the Mississippi alone, and over two thousand persons were by its ravages rendered homeless. A gentleman who witnessed the storm at the point of its greatest intensity, describes it as looking, when first observed, "merely like a threatening cloud ; but it soon assumed the appearance of a huge serpent, extending from the clouds to the earth, and twisting and writhing with an undulating motion, accompanied by a roaring more terrible than that of the mightiest cataract."

Tornadoes like these, though generally somewhat less intense and destructive than these, prevail every season, and rage with no less fury upon the lakes than upon the land ; and as they move almost uniformerly from west to east, or from south-

west to north-east, and at a rate of speed ranging generally from 20 to 40 miles an hour, there would seem to be no reason why such a system of storm-reporting as that just established by the Government should not be made immediately available in rendering invaluable service to our lake commerce. As to the entire practicability of the scheme there can be no question. General Myer, in a letter to General Paine upon the subject, quotes from the telegraphic news despatches in a single issue of a Washington newspaper a series of reports from different points in the West and Southwest, which together map out clearly the course and rate of progress of a storm of wind and rain that prevailed throughout a wide extent of territory in January last. These reports were made without any concert or system, of course, but show conclusively that valuable practical results may be easily attained through intelligent concert and system. Here are the different despatches:

"St Louis, *January* 17.—A terrible storm of thunder and lightning, wind and hail, passed over the city last evening."

"Chicago, *January* 17.—During the thunder-storm last night the mercury stood at 42 deg."

"Louisville, *January* 17.—A terrible tornado visited Cave City Station, on the Louisville and Nashville Railroad, at an early hour this morning."

"Cincinnati, *January* 17.—An unusually heavy storm of wind and hail, accompanied with thunder and lightning, occurred here this morning."

"Pittsburgh, *January* 17.—A heavy rain storm, with thunder and lightning, visited this city at noon to-day."

There is no difficulty in deducing from these data the fact that on the evening of January 16th a storm prevailed at St. Louis, which, moving easterwardly over a broad belt of territory, reached Chicago some time during the same night, Cave City Station the next morning, Cincinnati later in the morning, and Pittsburgh at noon of the 17th,—having traversed the distance from St. Louis to Pittsburgh in some 18 hours or at the rate of about 30 miles per hour. From the newspapers of the following day it might have been quite as easy to trace the storm on to the seacoast, and perhaps to gather particulars of the damage to shipping which it caused.

For several years the Smithsonian Institution has been collecting meteorological observations from all parts of the country, and laboring to deduce from the facts thus gathered the laws governing the phenomena of the weather and the climate; and the valuable results so gained can now be drawn upon in inaugurating the new system of storm-prediction and reporting. "The determination of the full details of this system will be arrived at," says General Myer in a communication to the Secretary of War, "only after careful study of the modes already tested in other countries, and consultation with experienced observers, telegraph companies, boards of commerce, and business men, as to their application or improvement in our own. There will need to be the study and determination of the points for observation; the supply of instruments, and the facilities for their use; the exact observations to be made; the exact form and times in which, when made, they are to be reported; the points at which reports are to be collected and deductions from them had; the places at which and the modes by which these deductions shall finally be announced, by telegraph and signal, and so made useful to the public, for the benefit of commerce, by the warning they may give or the aids they may offer. It is a wise provision of the act," he adds, "that it enables the army to be thus extensively utilized in the interest of commerce, by the exercise of duties already established, and which will require but additional outlay. It would be needless and unwise to enter upon large expenditures by attempting at the beginning too extended a scope for the endeavor. * * * I would suggest, therefore, that action under the resolution be limited, until the best modes for its execution shall have been wisely determined."

In accordance with this view, he asks for an appropriation for carrying out the law, of the modest sum of $15,000 for the current fiscal year, ending June 30, and $25,000 for the next fiscal year, ending June 30, 1871. As showing that the scheme is regarded with prompt favor by the interests it is designed to benefit, General Myer mentions the fact that the favorable proceedings upon the subject of six boards of commerce had, at the date

his communication, and within little more than a week after the approval of the joint resolution, been received at the office of the chief signal officer.

Professor Joseph Henry, of the Smithsonian Institution, writing to General Paine in approval of the objects of his joint resolution, points out the following conditions as essential to the success of the proposed system :

"1*st.* The points from which the telegrams are to be sent must be carefully selected and furnished with reliable instruments. 2*d.* These instruments must be in charge of persons properly trained to make the observations. 3*d.* The telegrams must be transmitted regularly to some central point at fixed hours of the day. 4*th.* They must at this centre be collated and their indications interpreted by persons having a competent knowledge of the laws to which the motions of the storms are subjected. 5*th.* I do not think the military posts as now established will be sufficient to fully carry out the plan ; additional stations would be required. 6*th.* An appropriation would be necessary for the pay of the telegrams, furnishing the instruments, and the necessary superintendence."

And Professor Elias Loomis, of Yale College, author of a valuable text-book upon Meteorology, writes to General Paine upon the same subject at length. He says :

"It is believed that our knowledge of storms is already sufficiently precise to enable a competent meteorologist to furnish information which would be of great value to commerce, provided he had at his command a sufficient corps of observers scattered over a considerable area to the west and south-west, and also had the means of transmitting his warnings immediately by telegraph ; and if such a system were pursued for several years, it could scarcely fail to conduce to more precise knowledge, which would render it possible to give more reliable and definite warning of the approach of dangerous storms.

"In order to secure the objects here contemplated, it would be indispensable to have observations from a pretty large number of stations at intervals not exceeding one or two hundred miles, and scattered over a region to the west and southwest of those points for which the warnings were regarded as specially important. These observations should include all the usual meteorological instruments, but more particularly the barometer, with the direction and force of the wind. The observations should be made daily at fixed hours, and should be reported by telegraph to some competent meteorologist, whose business it should be to compare the reports without delay, and make the proper deductions from them; and whenever a violent storm was in progress, to decide in what direction and with what velocity it was travelling; determine what places it would visit, and at what hour it would arrive ; and finally transmit the announcement immediately by telegraph to those places especially interested. Such a system could not be expected to attain satisfactory results without a pretty large number of well selected stations, and especially without the service of a competent meteorologist to superintend the entire system. The superintendent should be well informed respecting the progress which has been already made in this department of science ; he should have strong faith in the practicability of attaining useful results by a system of storm-warnings ; and he should have no other engagements which would prevent him from giving his whole attention to this subject, especially whenever a violent storm was raging in any part of the United States."

These coincident views of the two highest authorities in the United States upon all matters relating to meteorological science doubtless foreshadow substantially the actual working of the system when it shall have been fully established. In due time we may reasonably expect to see every light-house and other prominent and sightly point upon the borders of the great lakes and the Atlantic coast connected by telegraph with a central meteorological bureau, to which intelligence of an approaching storm can be simultaneously and speedily conveyed —to be in turn communicated, by means of a uniform system of signals, to all vessels within reach, in ample time to enable them to prepare for the coming danger.

That the results of the operation of this system will be in the highest degree valuable, both as regards the immediate practical object of protecting our commerce

from disaster, and as furnishing an aid to scientific investigation in a most important direction, there can be no reasonable doubt.

HEAT BY MEANS OF ILLUMINATING GAS.

From "Revue Industrielle."

"Gas as a combustible," said M. Cazin, at a recent scientific conference, "offers the best solution of the problem of distribution of motive power in large towns where the illumination by gas is already established. The pipes which furrow our cities convey a provision for light, for heat, and for motive force. We demanded primarily of the gas the first of these agents; we have demanded also the second; it is now time to demand of it all that it is capable of affording. Why should not the same apparatus afford to the workman in his shop light, heat, and power?

"When gas becomes cheaper this remarkable amelioration of the lot of the artisan will be realizable."

We will add that the obstacles to the employment of gas as a source of motive power arise not only from its high cost, but also from its disagreeable odor, and the absence of proper means for good combustion.

The odor which is produced chiefly at the commencement of the operation is produced by condensation of some of the products of the combustion upon a cold surface. It may be prevented in a great measure by previously heating the generator with another combustible.

With regard to an efficacious burner, we do not know of any; Bunsen burners, which are generally preferred, afford hardly one-half the calorific power contained in the gas.

The Parisian Company have directed a series of trials upon the calorific capacity of illuminating gas, which give sensibly the same results.

Copper tubular boilers were employed of a capacity of 10 to 30 litres. The heat was obtained from two Bunsen burners with flames from 20 to 25 centimetres high. The bottom of the boiler was placed so as to receive the flame at the height of 14 to 16 centimetres above the base.

The following table exhibits the results of the experiment:

Temperature of the Water.	Time of Heating.	Expenditure of Gas.	Gas used for each 10° of Heat.
Degrees.	Minutes.	Litres.	Litres.
10	..	..	..
35	10	160	64
60	15	188	78
80	15	191	95
90	7	100	100
100	7	100	100
	54	739	

The boiler weighed 6.5 kilogs.; it contained 29.5 kilogs. of water.

The number of calorific units produced was therefore $6.5 \times 9^* + 29.5 \times 90^\dagger =$ 2,713.5. This corresponds to 3,700 units to the cubic metre of the gas.

* Calorific capacity of the copper.

† Heat obtained from the gas.

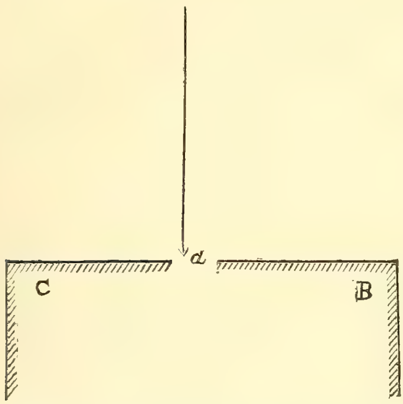
The mouth of the Rhone is obstructed by a bar of sand, which renders it inaccessible to sea-going vessels. The Government has undertaken, with the assistance of the local authorities, the excavation of a canal which shall admit such vessels into the Rhone, behind the bar, from the Bay of Fos. This canal, named the canal St. Louis, begins at the back of the bar, near the deserted town of St. Louis (in the main branch of the river), and ends in the north-western end of the Bay of Fos, known as the "Anse du Repos," or Bight of Rest, from its peculiar advantages as a harbor of refuge. The western end of the new canal will be closed by a lock, and the eastern end will open into a spacious harbor. The works are progressing rapidly, and it is expected that they will be completed by next August. The depth at the end of the main branch is from $1\frac{1}{2}$m. to $2\frac{1}{4}$m.; at the entrace of the new harbor is the Bay of Fos; it is 8m.; equal to 26 ft.

FORMULÆ FOR STRAINS IN TRUSSES AND THEIR PRACTICAL APPLICATION.

By S. H. SHREVE, A. M, LL.B., Member of American Society of Civil Engineers.

Let a be the point of application of a weight or vertical force to be transferred to the two supports B and C. It is self-evident that this cannot be done without the aid of horizontal forces of sufficient amount to change its direction to B and C; for no increase or decrease of the force at a can change its direction. It is also

Fig. 1.



evident that the amount of horizontal force depends upon the amount of the vertical force. The latter in the case of a weight upon a girder resting upon two supports, without lessening its own amount, creates sufficient of the former to carry it to the supports and no more; and as these two and their compounds are all the strains that can affect a girder, and as they are mutually dependent, it follows that from one of them, we can determine the other.

To do this we should use two well-known mechanical laws; that of the lever: "If a weight rest upon a beam supported at its extremities, the supports react with two upward pressures, whose sum is equal to the weight, and the proportion of the weight sustained by either support is to the whole weight as the remote segment is to the whole beam." No arrangement whatever of the truss can affect this law.

The other law is that of the equality of moments:

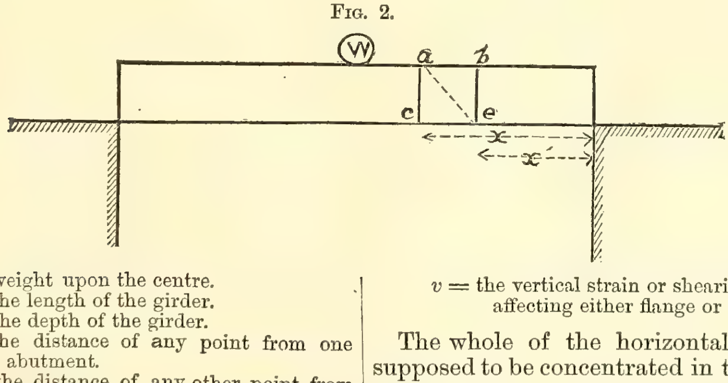
"If any number of pressures in the same plane be in equilibrium, and any point be taken in that plane from which their moments are measured, then the sum of the moments of these pressures which tend to turn the plane in one direction about that point, is equal to the sum of the moments which tend to turn it in the opposite direction."

The misapprehension of one of our authors renders it necessary to explain that the moment of a force referred to any point is the amount of the force multiplied by the distance perpendicular to the line of its direction.

All the cases which are investigated are those of girders or trusses with horizontal and parallel flanges or chords.

Case 1.—A girder supported at both ends and loaded at the centre only.

Fig. 2.



Let w = weight upon the centre.
l = the length of the girder.
d = the depth of the girder.
x = the distance of any point from one abutment.
x' = the distance of any other point from the same abutment.
H and H′ = the horizontal strains in either flange or chord at the points x and x'.
v = the vertical strain or shearing force not affecting either flange or chord.

The whole of the horizontal strain is supposed to be concentrated in the flanges at the points x and x', and the flanges receive no part of the vertical strain.

The moments around a point in the

lower flange of the girder directly under the weight are : the reaction of one abutment, $\frac{w}{2}$, multiplied by its distance from the point, $\frac{l}{2}$ or $\frac{w\,l}{4}$ in one direction; and to resist it, the horizontal strain in the upper flange, H, multiplied by its distance from the point d; the horizontal strain in the lower flange and such vertical strain as there may be, pass through the point, and consequently have no moments.

Therefore $\mathrm{H}\,d = \frac{w\,l}{4}$, or $\mathrm{H} = \frac{w\,l}{4\,d} \ldots$ (1)

In the same manner the strain in the lower flange can be shown to be of equal amount; but the latter is a strain of tension, while the former is one of compression.

Taking the moments around any other point in the lower flange, distant x from the same abutment as before, we have the reaction of the abutment, $\frac{w}{2} \times x$, its distance in one direction, and $\mathrm{H} \times d$ to resist it, or

$$\mathrm{H} = \frac{w\,x}{2\,d}, \qquad (2)$$

H in eq. (2) is less than the H of eq. (1), because x is less than $\frac{1}{2}$, or, the horizontal strain is greatest at the centre.

At any other point, x', between x and the abutment,

$$\mathrm{H}' = \frac{w\,x'}{2\,d} \qquad (3)$$

H′ is less than H because x' is less than x,

Subtracting,

$$\mathrm{H} - \mathrm{H}' = \frac{w\,x}{2\,d} - \frac{w\,x'}{2\,d} = \frac{w}{2\,d}\,(x - x') \qquad (4)$$

An amount of horizontal force that has disappeared from the flange between H and H′ and consequently has passed into the web. This it is evident it could not do unless a vertical force be united with it.

In the figure, let $a\,e$ represent the direction of the force that contains the difference of the horizontal forces, or H−H′. If $a\,b$ represent this amount of horizontal force, $b\,e$ will represent the vertical component of $a\,e$ and therefore,

$$a\,b : b\,e, \text{ or } x - x' : d :: \frac{w}{2\,d}(x - x') : \frac{w}{2} \qquad (5)$$

or the vertical force at any point in a girder loaded at the centre is equal to half the weight and is independent of the length and depth; and also of $x - x'$, which may be considered indefinitely small as in a girder with a continuous web.

These are all the strains that can affect this case :

A horizontal force, $\mathrm{H} = \frac{w\,x}{2\,d}$, at any point distant x from the abutment, in either flange.

A vertical force, $\mathrm{V} = \frac{w}{2}$, at any point in the web.

And where there is a diagonal, as in a truss, its strain is the resultant of $\frac{w}{2}$ vertical, and $\frac{w}{2\,d}\,(x - x')$ horizontal; x and x' being the respective horizontal distances of the ends of the diagonal from the abutment. Or if i be the angle between the diagonals and a vertical, $\frac{w}{2}$ sec. i, is the strain in any diagonal.

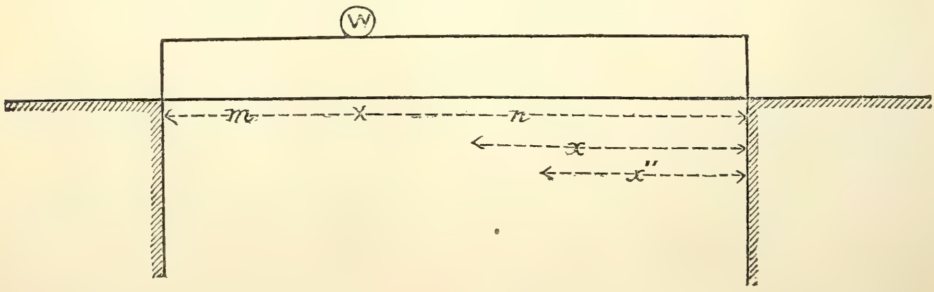
It will be seen from the above that the web conveys from one flange to the other an amount of horizontal force equal to the whole of that in either flange and in this manner one horizontal strain neutralizes the other.

As the horizontal force is only sufficient to carry the vertical force to the abutment, so the vertical force is only sufficient to neutralize the two horizontal strains by bringing them together.

Let the weight be moved nearer one abutment.

Case 2.

Fig. 3.



Let w = the weight.
m = the distance of the weight from the left abutment.
n = equal the distance of the weight from the right abutment.
$\frac{w}{l}m$ = the reaction of the right abutment by the principles of the lever.
$\frac{w}{l}n$ = the reaction of the left abutment.
$l.\ d.\ x.$ H. V. as before.

Taking the moments as before around a point under the weight, we have

$$H \times d = \frac{w}{l} m \times n$$

and
$$H = \frac{w\,m\,n}{d\,l}. \qquad (6)$$

(In this and the subsequent cases, where not otherwise mentioned, x will be measured from the right abutment and the reaction of that abutment considered.)

At any point x,

$$H = \frac{w\,m\,x}{d\,l}, \qquad (7)$$

At x',

$$H' = \frac{w\,m\,x'}{d\,l}, \qquad (8)$$

Subtracting,

$$H - H' = \frac{w\,m}{d\,l}(x-x'), \quad (9)$$

Using the same proportion as before.

$$x-x' : d :: \frac{w\,m}{d\,l}(x-x') : \frac{w\,m}{l} \quad (10)$$

In the same manner the vertical force between the centre and the left abutment can be shown to equal $\frac{w\,n}{l}$,

Or, the vertical force, in a beam loaded at one point, between that point and either one of the abutments, is equal to the reaction of that abutment.

As in the first case, we have now all the strains that can affect this case.

Case 3. A girder supported at both ends and loaded uniformly.

Let w = weight of the whole load.
$l.\ d.\ x.\ x.'$ H. H'. and V. be the same as before.
$x-x'$ is a constant quantity.
$u = \frac{x+x'}{2}$ or the distance from the same abutment from which x and x' are measured to a point midway between the two.

The moments around any point distant x from the right abutment, in the lower flange, are, the reaction of the abutment $=\frac{w}{2}$ multiplied by its distance x in one direction; and in the opposite the load on the part x, which is $\frac{wx}{l}$ multiplied by the distance of its centre of gravity from the point around which the moments are taken, which is $\frac{x}{2}$ and the horizontal strain in the upper flange H, multiplied by its distance d, whence

$$H\,d = \frac{w\,x}{2} - \frac{w\,x^2}{2\,l}, \text{ or } H = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,l} \quad (11)$$

This is the equation of the horizontal force in either flange of a uniformly loaded girder at any point distant x from the abutment.

If $x = 0$ or l, then $H = 0$.

If $x = \frac{l}{2}$; $H = \frac{w\,l}{8\,d}$, the horizontal strain at the centre.

In the same way

$$H' = \frac{w\,x'}{2\,d} - \frac{w\,x'^2}{2\,d\,l} \qquad (12)$$

As in the first case, H—H' represents the horizontal force which has united with a vertical force and passed into the web. This vertical force can therefore be obtained as before, from the proportion $x-x' : d$.

Subtracting, we have

$$H - H' = \frac{w}{2\,d}(x-x') - \frac{w}{2\,d\,l}(x^2-x'^2)$$

$$x-x' : d :: \frac{w}{2\,d}(x-x') - \frac{w}{2\,d\,l}(x-x')(x+x') :$$

$$\frac{w}{2} - \frac{w}{2\,l}(x+x') \qquad (13)$$

Since $u = \frac{x+x'}{2}$

$$V = \frac{w}{2} - \frac{w\,u}{l} \qquad (14)$$

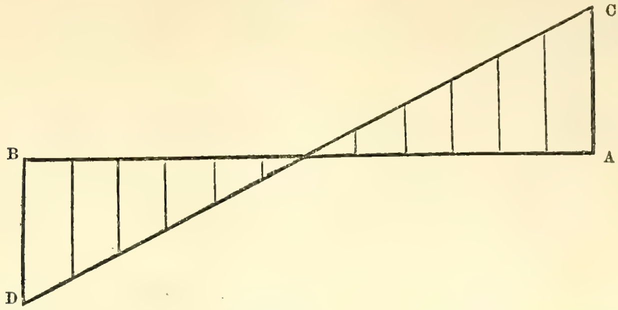
This is an equation giving the vertical strain at any point distant u from the abutment.

From eq. (14) it can be seen that the vertical force at any point is equal to half the weight less the weight between the point and the abutment.

This equation is entirely independent of d or the depth of the girder, and consequently is applicable to a rafter or an arch.

It is also the equation of a straight line as shown in the following figure, where the vertical force and the horizontal distance are the co-ordinates of any point in that line.

FIG. 4.



Let A be the origin; on the vertical axis make A C by a scale $= \frac{w}{2}$, and on the horizontal axis make A B $= l$, and D B $= \frac{w}{2}$ and join D C. The vertical lines will show the amount of vertical force at any point.

When $u = 0$, $V = \frac{w}{2}$,

If $u = l$, $V = -\frac{w}{2}$,

If $u = \frac{l}{2}$, $V = 0$.

When u becomes greater than $\frac{l}{2}$, V has the minus sign, showing that the weight at that point is carried to the other abutment. This is shown in the figure by the vertical lines below A B.

It is important to remember that the equation $V = \frac{w}{2} - \frac{wu}{l}$, is the same when u is measured from either abutment, that is if the equation be referred to either abutment; and when V has the $+$ sign the vertical force is passing to the abutment from which u is measured; when the opposite sign, then to the opposite abutment.

The origin of the axes in Figure 5, can be changed to the centre by making $\frac{w}{2} = 0$.

Then $V = \frac{wu}{l}$, is the equation of the vertical force, u being measured from the centre to the right or left.

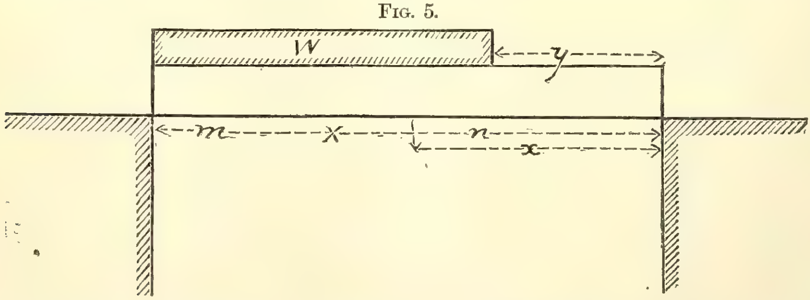
We have seen from the equations that the horizontal strain is the greatest at the centre and zero at the ends, and the vertical strain is greatest at the ends and zero at the centre.

If $x - x'$ be considered as indefinitely small, u may be considered equal to x, and the above statement can be proved by differentiating the horizontal equation and obtaining its maximum value, which will be found to be when $V = \frac{w}{2} - \frac{wx}{l} = 0$, or, when $x = \frac{l}{2}$.

Therefore, when either of these forces, the horizontal or the vertical, reaches its maximum the other becomes zero.

The point of greatest horizontal strain

FIG. 5.



is the dividing line between the weights, where the load on either side passes to the abutment on that side. No vertical strain passes this point.

Case 4.—A partially loaded girder supported at both ends.

Let $w =$ the weight.
$m =$ half the length of the loaded part.
$n = l - m$.
$y =$ the length of the unloaded part.
l, x, u, d, H, and V, as before.
$\frac{w}{l} m =$ the reaction of the right abutment.

$\frac{w}{l}n$ = the reaction of the left abutment.

The moments around a point in the lower flange distant x from the right abutment are, the moment of the right abutment $=\frac{wmx}{l}$ in one direction; the horizontal force H multiplied by d, and the moment of the load on

$$x-y=\frac{w}{2m}(x-y).\frac{x-y}{2}$$

in the opposite direction, whence

$$Hd=\frac{wmx}{l}-\frac{w}{4m}(x-y)^2.$$

And $$H=\frac{wmx}{dl}-\frac{w}{4dm}(x-y^2) \quad (15)$$

This equation will assume the form of eq. (11), by making $y=o$ and $m=\frac{l}{2}$ which would be the case for a girder fully loaded.

For a point x' between x and the right abutment within the loaded part,

$$H'=\frac{wmx'}{dl}-\frac{w}{4dm}(x'-y)^2 \quad (16)$$

The difference

$$H-H'=\frac{wm}{dl}(x-x')-\frac{w}{4dm}\left\{x^2-x'^2-2y(x-x')\right\} \quad (17)$$

We again obtain the vertical force from the proportion $\frac{d}{x-x'}$, which gives

$$V=\frac{wm}{l}-\frac{w}{4m}\left\{(x+x')-2y\right\} \quad (18)$$

putting $$u=\frac{x+x'}{2}$$

$$V=\frac{wm}{l}-\frac{w}{2m}(u-y) \quad (19)$$

Or the vertical force in this case is equal to the weight borne by the abutment less the weight on the part $(u-y)$. If the partial load be a constant load the point of greatest horizontal strain is when

$$V=\frac{wm}{l}-\frac{w}{2m}(u-y)=0.$$

The vertical force can also be found from the reaction of the left abutment.

In the equation

$$V=\frac{wm}{l}-\frac{w}{2m}(u\quad y)$$

V increases as u decreases until

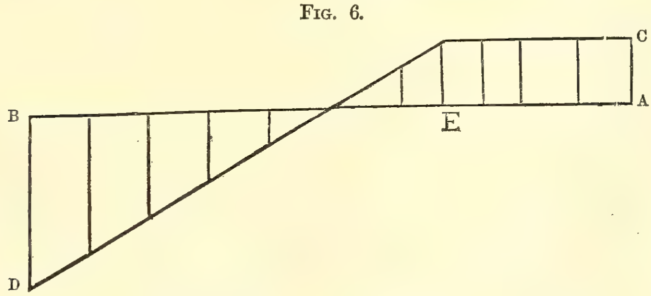
$u=y$, or $u-y=0$, when $V=\frac{wm}{l}$

or the vertical force at the end of the load and between it and the abutment is equal to the reaction of the abutment.

$$V=\frac{wm}{l}-\frac{w}{2m}(u-y)$$

can be represented as in Figure 6.

Fig. 6.



A B is the length of the girder, B D the weight borne by the left abutment, A C the weight upon the right abutment; B E the part of the girder covered by the load, the vertical lines representing the vertical strain at any point, those above A B have the + sign in the equation and pass to the right abutment; those below have the − sign and pass to the left abutment.

In the vertical equation

$$V=\frac{wm}{l}-\frac{w}{2m}(u-y)$$

w represents the partial uniform load upon a girder and is consequently a variable. It is necessary often, to have the amount of the full load whose weight per foot is the same.

Let w' = full load.

Then w of the above equation $=\frac{w'}{l}(l-y)$

And $2m=l-y$,

Whence

$$\frac{wm}{l}-\frac{w}{2m}(u-y)=\frac{w'(l-y)^2}{2l^2}-\frac{w'}{l}(u-y). \quad (20)$$

which is the equation of the vertical force at any point u under a uniform partial

load reaching to y where w' is the weight of a full load of the same density.

The greatest vertical strain at any point is when the girder is loaded from the abutment beyond the centre to that point.

For, let the load extend from the left abutment beyond the centre to a point distant u from the right abutment.

Then at the end of the load where $u = y$, eq. (20) becomes

$$V = \frac{w'(l-u)^2}{2\,l^2}, \qquad (21)$$

when

$$V = \frac{w'}{2} - \frac{w'\,u}{l} + \frac{w'\,u^2}{2\,l}. \qquad (22)$$

But at the same point under a full load (w') eq. (14).

$$V = \frac{w'}{2} - \frac{w'\,u}{l}.$$

Or, between the centre and the abutment, when the longer segment is loaded, the vertical strain is greater by the value of $\frac{w'\,u^2}{2\,l}$ than it is at the same point under a full load of equal weight per foot.

For example, under a full load the vertical strain at the centre is zero for $u = \frac{l}{2}$.

But when the girder is loaded to the centre $u = \frac{l}{2}$, and $V = \frac{w'}{8}$, or the vertical strain is one-eighth of a full load.

The equation of the horizontal strain under a partial load, where

w' = the weight of a full load of equal density.

y = the unloaded part.

x = any point under the load, is

$$H = \frac{w'\,(l-y)^2\,x}{2\,d\,l^2} - \frac{w'\,(x-y)^2}{2\,d\,l}, \qquad (23)$$

which reduces to the form,

$$H = \frac{w'\,x}{2\,d} - \frac{w'\,x^2}{2\,d\,l} - \frac{w'\,y^2}{2\,l}\,(1 - \frac{x}{l}). \qquad (24)$$

Under a full load the strain at the same point is

$$H = \frac{w'\,x}{2\,d} - \frac{w'\,x^2}{2\,d\,l},$$

or greater than the value of H in eq. (24).

Therefore the horizontal strain is greatest under a full load.

Eq. (21),

$$V = \frac{w'\,(l-u)^2}{2\,l^2},$$

is the equation of a parabola, whose vertex is at the abutment and whose diameter is vertical.

Case 5.—A girder supported at both ends and bearing two loads, one a constant load extending over its whole length; the other a partial load extending from one abutment to a point distant u from the other abutment.

Let w = the weight of the constant load.
w' = the weight of a full load whose weight per foot in length is equal to that of the partial load.
u = the distance between the end of the partial load and the abutment.
V = the vertical strain at any point from w.
V′ = the vertical strain at the end of the partial load.
l and d = the length and depth of the girder. We use V′ because it is the greatest vertical strain a partial load can cause.

From eqs. (14) and (21)

$$V = \frac{w}{2} - \frac{w\,u}{l}, \text{ and } V' = \frac{w'}{2\,l^2}\,(l-w)^2,$$

Adding

$$V + V' = \frac{w}{2} - \frac{w\,u}{l} + \frac{w'\,(l-u)^2}{2\,l^2} \qquad (25)$$

And we obtain an equation of the utmost value, which determines the amount of vertical force at any point in a bridge, resulting from the weight of the bridge itself and the weight of the passing load.

Considering u as measured from the right abutment, it is evident from eq. (25) that at the centre, $V + V' = \frac{w'\,(l-u)^2}{2\,l^2}$, for the vertical strain from the bridge itself at that point is 0, and the centre has therefore the same amount of the partial load to carry as is borne by the right abutment. As we move the load to the right of the centre, the vertical force from the bridge increases with the distance and the vertical force from the load increases as the ordinates of a parabola. But to the left of the centre there is a different effect produced; $-\frac{w\,u}{l}$ then becomes greater than $\frac{w}{2}$ showing a weight going to the left abutment, while $\frac{w'}{2\,l^2}\,(l-u)^2$ has the + sign and passes to the right abutment.

One of these forces neutralizes its amount in the other, as tension and compression cannot exist at the same

time in the same member. And if the value of

$$\frac{w}{2}-\frac{w\,u}{l}+\frac{w'\,(l-u)^2}{2\,l^2},$$

has the + sign the vertical force at that point is borne by the right abutment; if the — sign, it is borne by the left abutment.

If, however, its value is zero, there is no vertical force at that point as there is none in $\frac{w}{2}-\frac{w\,u}{l}$ at the centre.

Consequently beginning at the left end of the bridge, we can move our load on until eq. (25) = 0; as this occurs before we reach the centre, we are then at a point where we must first counterbrace, or brace to carry the weight towards the centre instead of towards the abutment, for then the equation begins to have the + sign.

As this point is of very great importance we will determine it from eq. (25); as u is measured from the right abutment and the load enters at the left end of the bridge, $l-u$ will be the distance from the left end to the point of counterbracing.

Put eq. (25)

$$\frac{w}{2}-\frac{w\,u}{l}+\frac{w'\,(l-u)^2}{2\,l^2}=0.$$

Let $w'=a\,w$, eliminate w and we have

$$\frac{1}{2}-\frac{u}{l}+\frac{al^2-2\,alu+a\,u^2}{2\,l^2}=0$$

Multiply by $2\,l^2$, divide by a and transpose, whence

$$u^2-2u\left(l+\frac{l}{a}\right)=-l^2-\frac{l^2}{a},$$

And

$$u^2-2u\left(l+\frac{l}{a}\right)+\left(l+\frac{l}{a}\right)^2=\left(l+\frac{l}{a}\right)^2-l^2-\frac{l^2}{a}$$

Whence

$$u-l=\frac{l}{a}-l\sqrt{\frac{1}{a}+\frac{1}{a^2}} \qquad (26)$$

Ex.—In a bridge whose weight is 150,000 lbs. and whose length is 200 ft., and whose full load is 300,000 lbs., at what distance from the end will counterbracing become necessary under a passing load of equal density with the full load.

Here

$$w=150{,}000$$
$$w'=300{,}000$$
$$a=\frac{w'}{w}=2.$$

Answer from eq. (26)

$$l=200.$$
$$\frac{l}{a}-l\sqrt{\frac{1}{a}+\frac{1}{a^2}}=\frac{200}{2}-200\sqrt{\frac{1}{2}+\frac{1}{4}}$$
$$=100-110\sqrt{3}=73.2\text{ ft.}$$

from the abutment.

DIAGRAM OF VERTICAL STRAINS (SEE FIG. 7).

Let A B = the length of the girder,

A G and B F, each $=\frac{w}{2}$, half the weight of the bridge.

A E and B D, each $=\frac{w'}{2}$ half the weight of the full load.

The vertical lines between A B and F G represent the vertical strains from the weight of the bridge.

The vertical lines between A B and D E represent the vertical strains from the weight of a full load.

Therefore the vertical lines between F G and D E represent the vertical strains from the weight of the bridge and the full load.

The weight of the bridge is a constant, but the load is not.

Let the bridge be loaded from B to L then L E‴ represents the portion of the load borne by the right abutment and B D‴ the portion borne by the left abutment, and the vertical lines between G F, D‴ E‴ H represent the vertical strains resulting from the weight of the bridge and the partial load from B to L. Instead of the point of no vertical strain being at c, the centre, it is now moved to the left to where the line E‴ H crosses the line G F. Counter braces would be needed from V to the centre.

Moving the load forward to L′ the vertical lines between D″ E″ and F E″ and between E″ G and E″ H, give the vertical strains, and E″ is the point of no vertical strain. It is here where the weight to the right abutment from the partial load equals the vertical strain to the left abutment from the weight of the bridge, and is the nearest point to the left abutment where counterbracing is needed. This is the point found by eq. (26).

B E‴ E″ E′ E is the parabola described by the vertical strains transmitted to the right abutment by the passing load and the equation of which is eq. (21).

An inverted parabola with its apex at A will give the strains for the left segment of the bridge; or the strains between E′

E″ G are to be applied to both ends of the bridge.

The following are assumed to be admitted without further demonstration.

The upper chord in a bridge of a single span is subject to compression only; the lower chord to tension only.

The weights may, without error, be con-

Fig. 7.

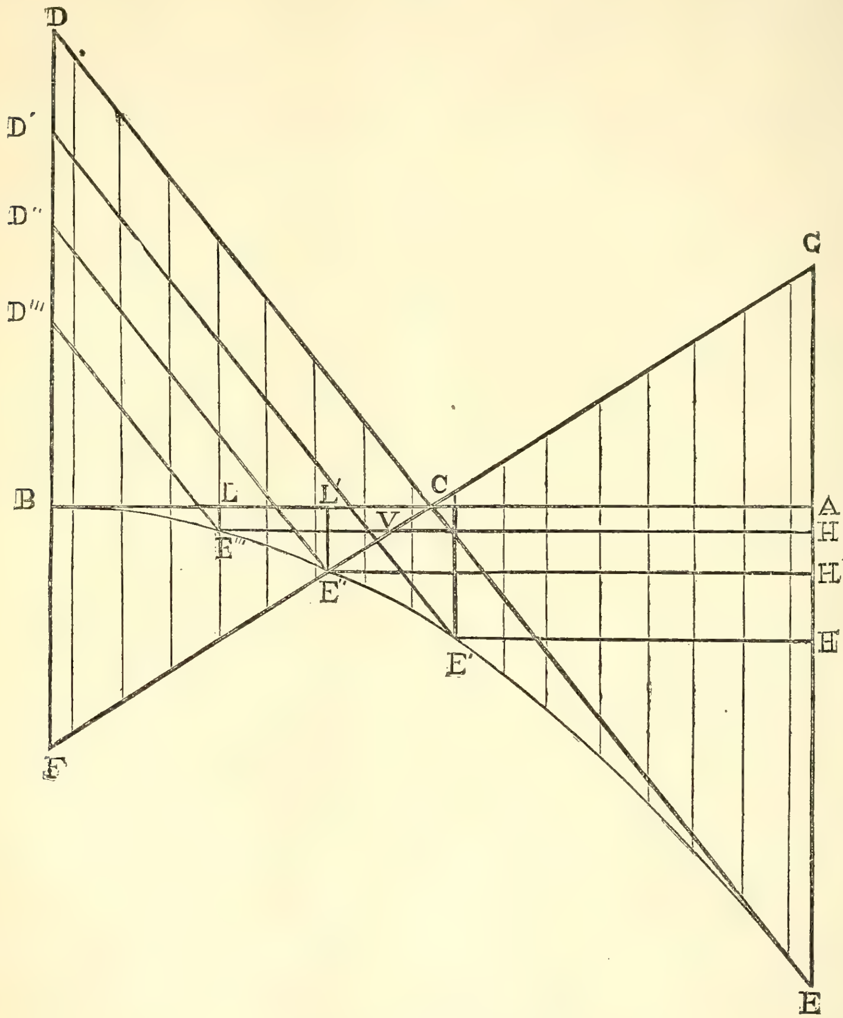


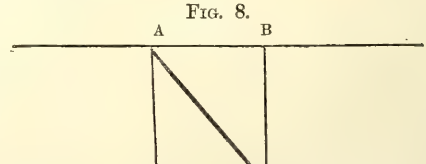
DIAGRAM OF VERTICAL STRAINS.

sidered as concentrated at the ends of the panels, each end supporting the weight resting on the adjacent half panels.

Within a panel there is no change in the strain affecting any one member of the panel, and all strains are longitudinal.

The load being considered as concentrated in weights at the ends of panels, only those inclined and vertical members which are between the weights belong to the same panel.

Fig. 8.



Let A B C D be a panel in a truss. If the weights are at A and B, the members of the panel are A B, C D, A D and D B;

if the weights are at C and D, the members are A B, C D, A C and A D. The panel belongs to that weight which it transfers toward the abutment.

The inclined and vertical members in a panel are subject to the same vertical strain. If the weights are at A and B in Fig. 9, the vertical strain, or the vertical component of the strain in A D is equal to the vertical strain in B D.

The chords receive no vertical strain whatever, and cannot convey a vertical strain from one point to another.

When the upper end of an inclined brace is nearer the centre of a fully loaded bridge or the point of no vertical strain in a partially loaded bridge, than the lower end, it suffers compression and is a strut; when the converse is true it suffers tension and becomes a tie.

The braces between the points of no vertical strain and the centre are counterbraces.

As there are some eccentric cases where the above definitions are not wholly true, a more general one would be: All braces which transmit strains from the upper to the lower chord are struts, those transmitting strains in the opposite direction are ties.

In the following examples application is made of the formulæ and methods given above. The first example is from Col. Merrill's "Iron Truss Bridges for Railroads," page 68, Plate V., and is termed by him the Jones Truss, more generally known as the Howe truss. The second example is from the same work, page 103, Plate IX., and is termed the Linville Truss, but which originated with Mr. Whipple.

The third is from Mr. Stoney's splendid work on "The Theory of Strains," Vol. I., page 98, and which is called a Warren Girder.

A comparison of the different methods of calculating will show so far as the vertical strains or strains containing vertical components are concerned a very great difference between the results obtained by Col. Merrill and those obtained below, and a small difference in the example taken from Mr. Stoney's work.

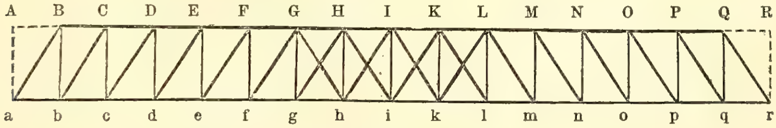
The horizontal strains are identical in the last case and would be in the first two had Col. Merrill made his calculations for a uniform load.

APPLICATION OF THE PRECEDING FORMULÆ.

Example 1st.

The inclined braces are struts; the vertical, ties.

Fig. 9.



HOWE TRUSS.

Let $l = 200$ feet, the length of the bridge.
$d = 18.75$ feet, the depth of the truss.
$w = 150,000$ lbs., the weight of the bridge.
$w' = 300,000$ lbs,, the weight of a full uniform load.
$x =$ distance of the end of a panel from one abutment.
$u =$ distance of the centre of a panel from one abutment.
The length of a panel is 12.5 feet.

To ascertain the horizontal strains in this truss which are greatest under a full load, we have eq. (14). (w being equal to $w+w'$).

$$H = \frac{(w + w')\, x}{2\, d} - \frac{(w + w')\, x^2}{2\, d\, l}$$

Whence

$$H = \frac{450.000\, x}{2 \times 18.75} - \frac{450.000\, x^2}{2 \times 18.75 \times 200} = 12000\, x - 60\, x_2$$

Putting $x = 12.5$, the distance of the ends of the first panels from the abutments,

$$H = 150,000 - 9375 = 140,625 \text{ lbs.}$$

the amount of horizontal compression at B and Q, and of horizontal tension at b and q. At B and Q the single members which sustain the whole compression are B C and P Q; at b and q the single members which sustain the whole tension are $a\ b$ and $q\ r$. The tension in $b\ c$ and $p\ q$ less the compression in $c\ b$ and P q is equal to that in $a\ b$ and $q\ r$.

In the same manner

When $x = 25$ ft., $H = 300,000 - 37,500 = 262,500$ lbs.

Compression in C D and O P, tension in $b\ c$ and $p\ q$.

When $x = 37.5$ ft., H = 450,000 − 84,375 = 365,625 lbs.

Compression in D E and N O, tension in $c\,d$ and $o\,p$.

When $x = 50$ ft., H = 600,000 − 150,000 = 450,000 lbs.

Compression in E F and M N, tension in $d\,e$ and $n\,o$.

When $x = 62.5$ ft., H = 750,000 − 234,375 = 515,625 lbs.

Compression in F G and L M, tension in $e\,f$ and $m\,n$.

When $x = 75$ ft., H = 900,000 − 337,500 = 562,500 lbs.

Compression in G H and K L, tension in $g\,h$ and $l\,m$.

When $x = 87.5$ ft., H = 1,050,000 − 459,375 = 590,625 lbs.

Compression in H I and I K, tension in $h\ i$ and $k\ l$.

When $x = 100$ ft., H = 1,200,000 − 600,000 = 600.000 lbs.

Tension in $h\ i$ and $i\ k$.

The above are the greatest strains that can affect any section of either chord. It will be seen from the above that the strains are the same in the two chords on the same side of any one brace.

To obtain the greatest vertical strains or the greatest strains having vertical components, we use eq. (25) giving the effect of the weight of the bridge and the passing load.

$$V = \frac{w}{2} - \frac{w\,u}{l} + \frac{w'\,(l-u)^2}{2\,l^2},$$

Substituting the values of the constants,

$$V = 75000 - 750\,u + 3.75\,(l-u)^2.$$

Making $u = 6.25$, the distance of the centre of the first panel from the abutment.

$$V = 75000 - 4687.5 + 140,771.5 = 211,084 \text{ lbs.}$$

for the vertical strain in a B and Q r, whose longitudinal strain of compression will be the vertical strain multiplied by the secant of the angle between the brace and the vertical; this secant is 1.20185.

$$211084 \times 1.20185 = 253,691 \text{ lbs.} =$$

compression in a B and Q r, and as the weight is on the lower chord, the ties B b and Q q belong to the first panels, and receive consequently the vertical strain of those panels, and are subject to a tension of 211,084 lbs.

When $u = 18.75$, $l-u = 181.25$,
V = 75,000 − 14,062.5 + 123,193.4 = 184,131 lbs.
Tension in C c and P p.
184 131 × 1.20185 = 221297.8 lbs.
Compression in C b and P q.

When $u = 31.25$, $l-u$ 168.75,
V = 75,000 − 23437.5 + 106787.1 = 158,350 lbs.
Tension in D d and O o.
158,350 × 1.20185 = 190,312.9 lbs.
Compression in D c and O p.

When $u = 43.75$, $l-u = 156.25$.
V = 75,000 − 32812.5 + 91,552.7 = 133,740 lbs.
Tension in E e and N n.
133,740 × 1.20185 = 150.735 lbs.
Compression in E d and N o.

When $u = 56.25$, $l-u = 143.75$,
V = 75,000 − 42,187.5 + 77,490.2 = 110,303 lbs.
Tension in F f and M m.
110,303 × 1.20185 = 132567 lbs.
Compression in F e and M n.

When $u = 68.75$, $l-u = 131.75$,
V = 75,000 − 51,562.5 + 64,599.6 = 88,037 lbs.
Tension in G g and L l.
88,037 × 1.20185 = 105,807 lbs.
Compression in G f and L m.

When $u = 81.25$, $l-u = 118.75$,
V = 75,000 − 60,937.5 + 52,880.8 = 66,943 lbs.
Tension in H h and K k.
66,943 × 1.20185 = 80,455 lbs.
Compression in H g and $K\ l$.

When $u = 93.75$, $l-u = 106.25$,
V = 75.000 − 70,312.5 + 42,333.9 = 47,022 lbs.
Tension in I i.
47,022 × 1.20185 = 56,513 lbs.
Compression in I h and I k.

We have now obtained the greatest tensions in all the ties, and the compressions in the main struts.

When $u = 106.25$, $l-u = 93.75$.
V = 75,000 − 79,687.5 + 32,958.9 = 28,272, and 28.272 × 1.20185 = 33,979 lbs.
Compression in H i and K i.

When $u = 118.75$, $l-u = 81.25$,
V = 75,000 − 89,062.5 + 24,755.9 = 10,694, and 10,694 × 1.20185 = 12,853 lbs.
Compression in G h and L k.

When $u = 131.75$, $l-u = 81.25$.
V = 75,000 − 98,437.5 + 17,724.6 = −5,713 lbs.

A strain that does not pass to the abutment from which u is measured, as indicated by the sign of the result, and as u is greater than half the length of the bridge, no counterbrace is now needed to carry any strain towards the centre.

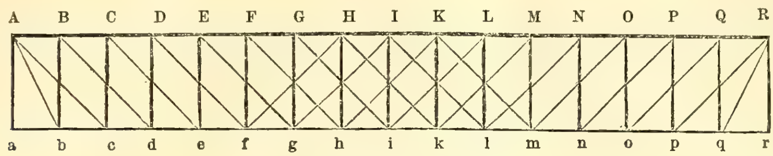
Referring to eq. (26) and the example given, we find that counterbracing becomes necessary at the distance of 73.2 feet from the abutment, which comes within the weight borne by the points g and l.

G h, H i, K i and L k, are all the counterbraces needed in this case.

Example 2d.

This truss is merely a combination of two simple trusses, each bearing half the weight, one of which is represented in Fig. 11, and is divided into panels of uniform length.

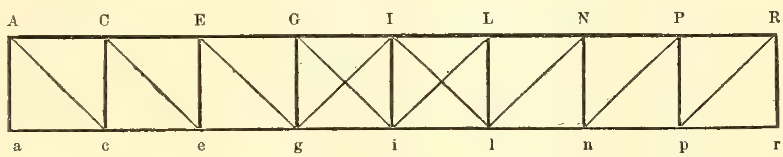
FIG. 10.



THE WHIPPLE TRUSS.

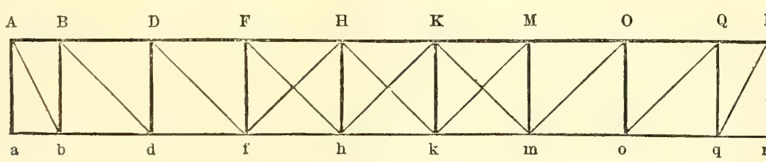
The other represented in Fig. 12 has all the panels of the same length as in Fig. 11, except the end panels, which are of half the length.

FIG. 11.



In this combination of two trusses, the horizontal strains of the two are united in the chords, but the members subject to vertical strains, or strains having vertical

FIG. 12.



components of one truss, act independently of the corresponding members of the other truss.

Let $l = 200$ ft., the length of the bridge.
$d = 25$ ft., the depth of the truss.
$w = 150{,}000$ lbs. the weight of the bridge.
$w' = 300{,}000$ lbs., the weight of a full uniform load.
$x =$ Distance of the end of a panel from one abutment.
$u =$ Distance of the centre of a panel of the simple truss from one abutment.
$p = 12.5$ ft., the length of a panel.

The simple truss of Fig. 11 can be determined by the application of the eqs. (11) and (15) with w equal to half of the weight of the bridge, and w' half the weight of the full load. But the other truss, Fig. 12, has the half panel at the ends, and prevents the application of eq. (11) in the general form of $\mathrm{H} = \frac{wx}{2d} - \frac{wx^2}{2dl}$, for the reason that while $\frac{wx}{2}$ is the moment of the abutment, $\frac{wx}{l}$ is not the weight on x and $\frac{x}{2}$ is not the distance of its centre of gravity. $\frac{w}{l}(x-p)$ (p being the length of the end panel) is the weight on x, and $\frac{x}{2}+\frac{p}{2}$ is the distance of its centre of gravity. Eq. (11) will therefore assume the form

$$\mathrm{H} = \frac{wx}{2d} - \frac{w}{dl}(x-p)\left(\frac{x}{2}+\frac{p}{2}\right) \qquad (27)$$

for the horizontal strains in simple truss (Fig. 12).

If x of eq. (27) be equal to M R in Fig. (12), H will be the horizontal strain in M O, D F, kf and fp.

If x in eq. (11) be equal to L R in Fig. (11), H will be the horizontal strain in L N, E G, $i\,l$ and $g\,i$. These two strains added will give M N, E F, $k\,l$ and $g\,h$ in Fig. 10.

Hence, the horizontal strain in the upper chord of Fig. (10) at any point is equal to the horizontal strain in that one

of the simple trusses whose panel end is at the same point, added to the strain in that panel end of the other simple truss that comes next towards the centre; or H at x in Fig. 10 is equal to H at x in one of the simple trusses added to H at $x+p$ in the other simple truss. And in the lower chord, H at x in Fig. 10 is equal to H at x in one of the simple trusses added to H at $x-p$ in the simple truss.

In equation (27) making $w=\frac{w+w'}{2}$ we get

$$H=\frac{(w+w')x'}{4d}-\frac{(w+w')}{2dl}\left(x'-p\left(\frac{x'}{2}+\frac{p}{2}\right)\right)$$

Make $x'=x+p$, and

$$H=\frac{(w+w')x}{4d}+\frac{p(w+w')}{16d}-\frac{(w+w')x^2}{4dl}-\frac{p(w+w')x}{2dl}$$

Adding this to

$$H=\frac{(w+w')x}{4d}-\frac{(w+w)x^2}{4dl}.$$

We obtain

$$H=\frac{(w+w')x}{2d}-\frac{(w+w')x^2}{2dl}-\frac{p(w+w')x}{2dl}+\frac{p(w+w')}{4d} \qquad (28)$$

for the horizontal strain at any point in the upper chord of Fig. 10, and in the same manner with $x'=x-p$, we get

$$H=\frac{(w+w')x}{2d}-\frac{(w+w')x^2}{2dl}+\frac{p(w+w')x}{2dl}-\frac{p(w+w')}{4d} \qquad (29)$$

for the horizontal strain in the lower chord at any point x.

Substituting the constants eq. (28) we obtain

$$H=8437.5\,x-45\,x^2+56{,}250.$$

When $x=12.5$

$H=105{,}468.75-7{,}031.25+56{,}250=154{,}687.5$ lbs.

Compression in Q R and A B, and tension in *c d and o p.*

When $x=25.$

$H=210{,}937.5-28{,}125+56{,}250=239{,}062.5$ lbs,

Compression in R Q and B C, and tension in *d e* and *n o*.

When $x=37.5.$

$H=316{,}406.25-63{,}281.25+56{,}250=309{,}375$ lbs.

Compression in O P and C D, and tension in *e f* and *m n*.

When $x=50.$

$H=421{,}875-112{,}500+56{,}250=365{,}625$ lbs.

Compression in N O and D E, and tension in *f g* and *l m*.

When $x=62.5.$

$H=527{,}343\ 75-175{,}781.25+56{,}250=407{,}812.5$ lbs.

Compression in M N and E F, and tension in *g h* and *k l*.

When $x=75.$

$H=632{,}812.5-253{,}125+56250=435{,}937.5$ lbs.

Compression in L M and F G, and tension in *h i* and *i k*.

When $x=87.5.$

$H=738{,}281.25-344{,}531.25+56{,}250=450{,}000$ lbs.

Compression in G H and K L.

When $x=100.$

$H=843{,}750-450{,}000+56{,}250=450{,}000$ lbs.

Compression in H I and I K.

The tension in $b\ c$ and $p\ q$ can he found from eq. (29), where

$$H=9562.5-45\,x^2-56{,}250.$$

When $x=12.5.$

$H=119531.25-7031.25-56{,}250=56{,}250$ lbs.

When $x=25.$

$H=239062.5-28125-56{,}250=154{,}687.5$ lbs.

Tension in *c d and o p*,

same as found in the upper chord on the same side of same inclined brace.

As there is no connection between the members of the two simple trusses subject to vertical strains, in the compound truss, equation (25) will retain the same form. w and w' necessarily becoming $\frac{w}{2}$ and $\frac{w'}{2}$, each simple truss bearing half the weight of the full load and of the bridge. u being the distance to the centre of a panel of the simple trusses, becomes the distance to the end of a panel of a compound truss, and since the truss in Fig. 12 has the centre of the end panel at the end of the truss, the first value of V is when $u=0$.

Substituting the values of the constants,

$$V=\frac{w}{4}-\frac{wx}{2l}+\frac{w'(l-u)^2}{4l^2}=37500-375\,u+1.875\,(l-u)^2,$$

When $u=0.$

$V=37500+75000=112{,}500$ lbs.

Compression in end posts A a and R r.

and $112{,}500\times1.20185$ the secant of the angle Q q R $=135208$ lbs. tension in ties q R and A b.

When $u=12.5.$

$V=37500-4687.5+32812.5=98731$ lbs.

Compression in end posts A a and R r, which added to the amount obtained previously makes the total amount of compression in these posts to be 211,231 lbs.

98731×1.414 secant of angle R $p\ r=139626$ lbs. Tension in *p R* and *A c*.

When $u = 25$.

$V = 37500 - 9375 + 57422 = 85,547$.

Compression in Q q and B b.

$85.547 \times 1.414 = 120,963$ lbs.

Tension in o Q and B d.

When $u = 37.5$.

$V = 37500 - 14062 + 49512 = 72,949$ lbs.

Compression in P p and C c.

$72,949 \times 1.414 = 103,150$ lbs.

Tension in n P and C e.

When $u = 50$.

$V = 37500 - 18750 + 42188 = 60938$ lbs.

Compression in O o and D d.

$60938 \times 1.414 = 86,166$ lbs.

Tension in m O and D f.

When $u = 62.5$.

$V = 37500 - 23438 + 35449 = 49512$ lbs.

Compression in N n and E e.

$49512 \times 1.414 = 70010$ lbs.

Tension in l N and E g.

When $u = 75$.

$V = 37,500 = 28125 + 29297 = 38672$ lbs.

Compression in M m and F f.

$38672 \times 1.414 = 54,682$ lbs.

Tension in k M and F h.

When $u = 87.5$.

$V = 37500 - 32812 + 23730 = 28418$ lbs.

Compression in L l and G g.

$28418 \times 1.414 = 40183$ lbs.

Tension in i L and G i.

When $u = 100$.

$V = 37500 - 37500 + 18750 = 18750$ lbs.

Compression in K k and H h.

$18750 \times 1.414 = 26413$ lbs.

Tension in h K and H k counterbraces.

When $u = 112.5$.

$V = 37500 - 42187 + 14355 = 9668$ lbs.

Compression in l i.

$9668 \times 1.414 = 13670$ lbs.

Tension in g I and I l, counterbraces.

When $u = 125$.

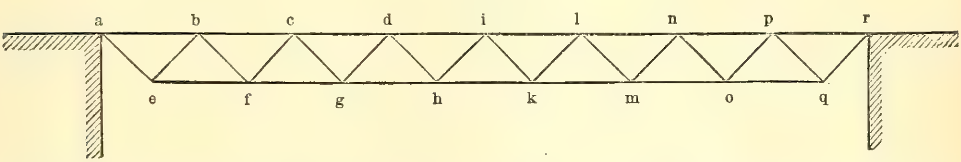
$V = 37500 - 46875 + 10547 = 1172$ and

$1172 \times 1.414 = 1657$ lbs.

Tension in f H and K m, counterbraces.

When $u = 137.5$ r has the minus sign, or the weight no longer passes to the abutment from which u is measured, and consequently no more counterbraces are necessary.

FIG. 13.



Let Fig. 13 represent a Warren Girder the bracing of which is formed of eight right angled isosceles triangles, with the roadway attached to the upper flange or chord. Let the permanent bridge load equal half a ton per running foot and the greatest passing train of uniform density equal to one ton per foot.

$w = 40$ tons.
$w' = 80$ tons.
$l = 80$ feet.
$d = 5$ feet.

The length of a panel is the distance on the upper chord between the apices of the triangles, which is 10 feet.

x = The distance of the apex of any triangle from the abutment.

u = The distance of the centre of a panel from one abutment.

Applying the horizontal equation (11)

$$H = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,l}$$

with x equal to the length of one panel, we get the horizontal strain at b in the upper chord, and the horizontal strain in $e\,f$ of the lower chord; but the strain at b is partly in $b\,c$ and partly in $b\,f$ and we have no single member at that point to sustain the whole horizontal strain. The equation, however, can be adapted to points at the centres of the panels.

Let x' = distance of the centre of any panel from the abutment.

h = half the length of a panel.

$\frac{w\,x'}{2}$ will be the moment of the reaction of the abutment, and $\frac{w}{l} \times h \times x'$ will be the moment of the half panel load resting immediately on the abutment.

$\frac{w}{l}(x'-h)$ is the balance of the load upon x' and.

$\frac{x'-h}{2}$ is the distance of its centre of gravity.

Whence

$$H = \frac{w\,x'}{2\,d} - \left\{ \frac{w\,x'^2}{2\,d\,l} + \frac{w\,h^2}{2\,d\,l} \right\}, \qquad (30)$$

An equation giving the strains in the upper chord of a Warren Girder, where x' is the distance of the apices of the inverted triangles on the lower chord, and h half the length of a panel, and w the weight of the full load and the bridge.

Substituting the values of the constants, we get

$$H = 12\,x' - \frac{3x'^2}{20} - 3.75.$$

With $x' = 5$.

$H = 60 - 3.75 - 3.75 = 52.5$ tons.

Compression in $a\,b$ and $p\,r$.

When $x' = 15$.
$H = 180 - 33.75 - 3.75 = 142.5$ tons.
Compression in $b\,c$ and $n\,p$.

When $x' = 25$.
$H = 300 - 93.75 - 3.75 = 202.5$ tons.
Compression in $c\,d$ and $l\,n$.

When $x' = 35$.
$H = 420 - 183.75 - 3.75 = 232.5$ tons.
Compression in $d\,i$ and $i\,l$.

For the lower chord substitute the constants in

$$H = \frac{(w + w')\,x}{2\,d} - \frac{(w + w')x^2}{2\,d\,l},$$

Whence $$H = 12\,x - \frac{3\,x^2}{20}$$

When $x = 10$.
$H = 150 - 15 = 105$ tons.
Tension in $e\,f$ and $o\,q$.

When $x = 20$.
$H = 240 - 60 = 180$ tons.
Tension in $f\,g$ and $m\,o$.

When $x = 30$.
$H = 360 - 135 = 225$ tons,
Tension in $g\,h$ and $k\,m$.

When $x = 40$.
$H = 480 - 240 = 240$ tons.
Tension in $h\,k$.

Substituting the values of the constants in

$$V = \frac{w}{2} - \frac{w\,u}{l} + \frac{w'\,(l-u)^2}{2\,l^2},$$

We get

$$V = 20 - \frac{u}{2} + \frac{(l-u)^2}{160},$$

When $u = 5$.
$V = 20 - 2.5 + 35.15 = 52.65$ multiplied by 1.414 secant of the angle of inclination of the brace $= 74.4$ tons.
Compression in $p\,q$ and $b\,e$, and tension in $a\,e$ and $q\,r$.

When $u = 15$.
$V = 20 - 7.5 + 25.75 = 38.28$, and $\times$ 1.414 $= 54.1$ tons.
Compression in $n\,o$ and $c\,f$, and tension in $b\,f$ and $o\,p$.

When $u = 25$.
$V = 20 - 12.5 + 18.9 = 26.4$ and $\times$ $1.414 =$ 37.3 tons.
Compression in $l\,m$ and $d\,g$, and tension in $m\,n$ and $c\,g$.

When $u = 35$.
$V = 20 - 19.5 + 12.65 = 15.15$, and $\times$ 1.414 $= 21.4$ tons.
Compression in $i\,k$ and $i\,h$, and tensiou in $k\,l$ and $d\,h$.

When $u = 45$.
$V = 20 - 22.5 + 7.66 = 5.16$ and $\times$ $1.414 =$ 7.3 tons.
Compression in $d\,h$ and $k\,l$, and tension in $h\,i$ and $i\,k$.

When $u = 55$, V has the minus sign, and there is no further need of counterbracing.

It will be observed that $d\,h$, $h\,i$, $i\,k$ and $k\,l$ are subject to both tension and compression under a moving load, and are consequently counterbraces. The other braces are subject to either tension or compression only and are main braces.

Comparing this with the formula for the commencement of counterbracing, eq. (26.)

$$\frac{l}{a} - l\sqrt{\frac{1}{a} + \frac{1}{a^2}}$$
$$l = 80 \qquad a = 2$$

We obtain 29.2 ft., or counterbracing becomes necessary at 29.2 ft. from the abutment, which is within the weight borne by the third apex.

There is a slight difference between these results, and those obtained by Mr. Stoney, amounting in the strains to which the braces are subject to about $\frac{1}{10}$ of a ton; but the results as regards the horizontal strains and the counterbracing are identical.

The difference in the strains affecting the braces can be easily explained. Though Mr. Stoney considers the passing load equal to 1 ton per running foot, he makes 35 tons instead of 40 tons, a load covering half the girder. His partial load never extends from the abutment to the centre of a panel, but from a point half way between the abutment and the first apex. He begins by estimating the strains resulting from a weight on b, of 10 tons, then adds the weight on c, etc. But this is an almost impossible case. If b be fully loaded, and the end of the train half way between b and c, the girder will certainly be loaded to a, and the right abutment will have its proportion of 15 tons, instead of 10 tons, to bear. The difference, however, is small, and is a constant, as can be seen from the equation.

M. Cotelle, says the "Pharmacist," has invented a cheap substitute for the platinum still used in distillation of sulphuric acid. It consists of a stone tower, into which the acid drops in small quantities, while a current of hot air enters at the bottom and drives over the acid, which is condensed in the usual way.

According to "Cosmos," the vapor which is frequently disengaged on the first application of heat to the oxide of copper in the combustion tube, used in organic analysis, arises from the presence of a small quantity of selenium. M. Violette is credited with the discovery.

TWO-STORIED RAILWAY CARRIAGES.

From "Engineering."

For more than 20 years past there have been extensively used on some of the French railways carriages with seats on the roof, or "voitures à impériale," as they are usually called. According to a recent return the Western Railway of France possessed 526, the Eastern Railway, 236, and the Northern, 150 of these carriages, and the results obtained by their employment appear to be in every way satisfactory, it being found that they ride easily, and that they are no more liable to derailment than ordinary single-storied vehicles. The "voitures à impériale" are principally employed for the local traffic in the neighborhood of Paris, and in summer time, when the heat is great, it is no uncommon thing for the roof seats to be completely filled, whilst those in the lower body are almost empty; yet, notwithstanding this apparently somewhat risky method of loading, and the liability to derailment which it might be supposed to induce while the trains were traversing curves, we believe that no accident has ever occurred which could be fairly attributed to this cause. In some degree this result is no doubt due to the fact that in the ordinary "voitures à impériale," the upper seats and the roof or awning which covers them are made as light as possible, while at the sides the upper body is left open, no protection whatever from the weather being provided. At some seasons of the year this is a considerable defect, and it was with a view of remedying it, and at the same time retaining the advantages of the "voitures à impériale," that M. J. B. Vidard, a few years ago, introduced the regular two-storied carriages, such as are now in use on the Eastern Railway.

In these carriages, of which we published engravings and a description about 3 years ago (*vide* page 207 of our third volume), the upper seats are contained in a regular "body" provided with side windows and end doors, while to prevent the centre of gravity from being raised too high, the frame is lowered so that the lower body is at a much less height above the rails than usual. By this means, and by keeping the heights of the compartment rather small—the lower body being but 5 ft. 5 in. high at the centre—the total height of the carriages is kept down to less than 13 ft. 8 in., while the centre of gravity is not greatly higher than that of ordinary vehicles, as the following Table lately prepared by M. Vidard, will show.

Class of Vehicles.	Weight of each Part of the Carriage.	Height of the Centre of Gravity of each Part of the Carriage.		Weight of each Part added successfully to that of the Parts Preceding.	Height above Rail of the Centre of Gravity of the Weight given in the preceding Column.
		Above the Centre of Gravity of the preceding Part.	Above the Rail Level.		
Ordinary 2d Class Carriage:	cwt.	ft. in.	ft. in.	cwt.	ft. in.
Two pairs of wheels, axles, etc	34	1 7½	1 7½	34	1 7½
Frame	38	1 7½	3 3	72	2 6¼
Body	54	2 11½	6 2½	126	4 1¼
"Voiture à Impériale:"					
Two pairs of wheels, axles, etc	32	1 7½	1 7½	32	1 7½
Frame	48	1 7½	3 3	80	2 7½
Lower body	60	2 10½	6 1½	140	4 1½
Impériale	18	4 9⅛	10 10⅝	158	4 11
Two-Storied Carriage:					
Two pairs of wheels, axles, etc	30	1 5¾	1 5¾	30	1 5¾
Frame	40	0 11⅞	2 5⅛	70	2 0½
Lower body	60	4 11	7 4⅝	130	3 4⅜
Upper body	26	3 1¾	10 6⅜	156	4 6⅛

It will be seen from this Table, that the heights above rail level, of the centres of gravity of the ordinary carriages, the "voitures à impériale," and M. Vidard's two-storied carriage, are respectively 4 ft. $1\frac{1}{4}$ in., 4 ft. 11 in., and 4 ft. $6\frac{1}{8}$ in., these heights referring to the position of the centres of gravity with the carriages empty. When the vehicles are loaded, the low position of the seats in the Vidard carriages causes their centre of gravity under those circumstances to be still further below that of the "voitures à impériale."

The Table also shows that if the Vidard carriage had the upper story removed, its centre of gravity would then be but 3 ft. $4\frac{3}{8}$ in. above the rail level, or $9\frac{7}{8}$ in. below that of a carriage of ordinary construction, and this is a point which under some circumstances might render it advisable to adopt the lowered frame used by M. Vidard even when the upper story was not required. In the case of cheaply constructed branch lines, moreover, where it is desired to avoid the erection of platforms, the lowered frame enables ready access to be had to the compartments with but a single step. On such lines as those we have just mentioned, we believe that two-storied carriages constructed on M. Vidard's plans could be very advantageously employed, as their dead weight is really very small in proportion to the load carried. Thus the Vidard carriages on the Eastern Railway of France carry from 68 to 80 persons according to the class, those carriages accommodating 80 passengers being entirely third class. In all cases 40 third class passengers are accommodated in the upper body, and it will be seen, on reference to the Table, that this accommodation is obtained with an increase of weight of but 30 cwt., as compared with that of an ordinary second class carriage. The total weight of one of these two-storied carriages fully loaded is about 13 tons, or about $3\frac{1}{4}$ tons per wheel, and this is a load which is by no means excessive, even for a "light" railway. In this country, where we have of late years become accustomed to lofty and roomy carriages, we do not believe that the somewhat cramped proportions of the Vidard carriages would be tolerated on our principal lines, even for short distance traffic. In the case of country branch lines, however, or in the case of the economically constructed light railways, which are likely, before many years are over, to spring up in numerous districts, the case is different, and we believe that those interested in the construction and working of such lines might turn their attention to two-storied carriages with advantage.

A Puzzling Possibility.—When the Russian-American Telegraph is completed, the following feat will be possible: A telegram from Alaska for New York, leaving Sitka, say at 6.40 Monday morning, would be received at Nickolaef, Siberia, at 6 minutes past 1 on Tuesday morning; at St. Petersburg, Russia, at 3 minutes past 6 Monday evening; at London at 22 minutes past 4 Monday afternoon; and at New York at 46 minutes past 11 Monday forenoon. Thus, allowing 20 minutes for each re-transmission, a message may start on the morning of one day, to be received and transmitted the next day, again received and sent on the afternoon of the day it starts, and finally reach its destination on the forenoon of the first day. The whole taking place in one hour's time.

Railways are all the vogue in Chili and Peru. The Concepcion and Chilian line progresses rapidly. A road is projected across the Andes. On the 1st of February last a railway from Callao to Oroya was commenced, the latter point being connected by navigable rivers with the Atlantic Ocean. Another new line is being made in Peru to run from Arequipa to Puno, and thus connect the Pacific with Lake Titicaca. The Oroya line will be 222 miles long, with 27 tunnels and 17 bridges; the cost is put down at $27\frac{1}{2}$ million dollars, the Government giving 6 per cent. interest and 2 per cent. amortisation. The Arequipa line will be 137 miles long, with 12 great tunnels, and costing 32 million dollars.

Pennsylvania has produced 28,000,000 barrels of petroleum in 10 years; and a larger quantity has been brought from the bowels of the earth, during the last year, than was brought forward in the height of the "oil fever."

DOUBLE STEAM BOILERS.

From "Engineering."

M. C. Felix, of Paris, has recently communicated to the "Bulletin Mensuel de la Société des Anciens Elevés des Ecoles Imperiales d'Arts et Metiers," a proposal for a system of double steam boilers, which, though not absolutely novel, nor yet perhaps capable of very general application, is yet well worthy of some notice in our pages. The system advocated by M. Felix is a very simple one, and consists merely in adding to an ordinary boiler a second boiler so arranged that it is heated by the steam in the first. Thus, in one case, it is proposed to provide the first boiler with a dome of unusual size, this dome being divided horizontally by a plate, from which tubes depend into the steam space of the boiler. The upper part of the dome above the division plate forms, in this case, the boiler from which the steam is drawn for the supply of the engine.

The first boiler is heated by a fire in the usual way, but inasmuch as all the steam formed in it is condensed by contact with the tubes of the second boiler, the contained water is evaporated over and over again, and the only fresh supply needed is that required to make up losses by leakage. It is claimed as one of the advantages of the system, that inasmuch as there is no renewal of the water in the first boiler (except the slow renewal rendered necessary by leakage) there can be no formation of incrustation on the surfaces exposed to the fire; while, on the other hand, in the second boiler—where of course incrustation will form as usual—none of the surfaces incrusted are exposed to a higher temperature than that of the steam in the first boiler. These are, of course, undoubted advantages, but whether they are of such great value as to outweigh the extra cost of a boiler constructed on the "double" system is another matter ; in some instances we believe they may have this value, but certainly not in the majority of cases.

It is, of course, necessary in order that the heat may be freely communicated from the first to the second boiler, that the former should be worked at a higher pressure than the latter. M. Felix proposes a difference of pressure of two atmospheres, or about 30 lbs. per square inch, and of course the higher the difference of pressure, and the greater therefore the difference between the temperature of the steam in the two boilers, the less will be the area of heat-absorbing surface which it will be necessary that the second boiler should have in order to supply a given quantity of steam. M. Felix assumes as the basis of his calculations concerning the requisite area of what we may term the intermediate heating surface, that one square metre of such surface will evaporate 8 kilogammes of water per hour for each degree (centigrade) of difference of temperature between the steam and water. Reduced to English dimensions, this is equal to an evaporation of about 0.9 lbs. of water per sq. ft. of steam-heated surface per degree (Fahr.) of difference of temperature between the steam and water. No doubt, results as high as this have been obtained in certain cases where there has been a rapid circulation of water over the steam-heated surfaces ; but these are exceptionable instances, and in ordinary practice—taking into consideration that the surfaces are liable to become coated with incrustation—it would not be safe to depend upon a rate of heat transmission more than one-third as great as that above mentioned, or say, a transmission equal to the evaporation of 0.3 lb. of water per square foot of surface per hour per degree of difference of temperature.

With steam at a pressure of 90 lbs. per square inch in the first, and 60 lbs. per square inch in the second boiler, there would be an available difference of temperature of about 24 deg., and according to the data just given the evaporation in the second boiler would thus be equal to $24 \times 0.3 = 7.2$ lbs. per square foot of "intermediate" heating surface per hour. In other words, about 8.7 square feet of "intermediate" heating surface would be required for each cubic foot of water to be evaporated per hour in the second boiler —an area which would probably render the cost of the double boiler nearly, or quite, equal to that of two boilers of equal power constructed on the ordinary system.

IRON AND STEEL NOTES.

The Iron Trade in France.—The markets of the Haute Vienne are in good condition, business satisfactory and impressions favorable ; quotations all firm, and in some instances on the rise. Charcoal iron very scarce, and not to be had under 125 f. Wrought iron in good demand as regards machine iron and its derivations at the following rates :—Coke iron, rolled, 200 f. to 225 f. ; mixed ditto, first quality, 220 f. to 225 f. ; charcoal, ditto, first quality, 235 f. to 240 f. ; ditto, second quality, 225 f. to 235 f. The works that produce rod and machine iron have orders in hand for several months ahead. Good qualities of mixed iron for drawing, worth 235 f. to 240 f. Machine iron for chain work about the same. Hammered iron stands at 245 f. to 250 f. for bar, and at 250 f. to 255 f. for axles. Iron wire and nails are in demand and on the rise. The drought has caused a falling off in the make, but the late fall of rain will have corrected this. The entries of special cast and wrought iron in Paris for building purposes continue to fall off, as compared with the amounts of former years, as will be seen by the following returns for three years :—Wrought iron, month of March, 1870, 2352 tons ; 1869, 3652 tons ; 1868, 4305 tons ; cast iron, 1870, 759 tons ; 1869, 1318 tons ; 1868, 1321 tons. Wrought iron, first quarter of the year, 1870, 4999 tons ; 1869, 10,101 tons ; 1868, 1370 tons ; cast iron, 1870, 2396 tons ; 1869, 3964 tons ; 1868, 3359 tons. The inquiry respecting the textile industries is expected to be completed during the next fortnight, when that relating to the metal trades will be taken in hand.—*The Engineer.*

Not infrequently does an iron ore from a particular bank or locality acquire from the furnace-master a reputation for cold or red-short tendencies which does not justly belong to it, from the fact of the presence of notable amounts of sulphur and phosphorus in the flux used with it. As the analysis of limestones are most generally conducted, the presence of these elements is either overlooked or their quantities are not estimated. We believe that if this point were properly and fairly appreciated, many variations in a furnace's product would be understood, and a proper corrective applied. Some time since, with this special object in view, we examined into some limestones employed at different furnaces, and in all our samples found both sulphur and phosphorus, the former probably existing as sulphuret of iron or sulphate of lime, and the latter as phosphate of the same base. The following result, centesimally expressed, will illustrate to what amount these substances may exist and yet be overlooked unless special research be made for them :—

Carbonate of lime 86.23, carbonate of magnesia 2.82, phosphate of lime 0.87, sulphate of lime 0.28, alumina and oxide of iron 1.01, matter insoluble in acids 8.25, organic matter 0.28, = 99.74.

The amount of phosphate of lime corresponds to 0.17 per cent. of phosphorus, or 3.4 lbs. to every ton ; that of the sulphate to 0.06 per cent. of sulphur, or 1.2 lb. to the ton. The specimen was of a brecciated structure, and was from a Pennsylvanian locality. When the circumstances under which limestones are formed are properly considered, it must be evident that these, as well as other foreign matters, must necessarily be present in greater or less amounts. Most of them, when properly examined, will exhibit also noteworthy amounts of the alkalies, probably existing in the condition of chlorides.—*American Exchange and Review.*

The Manufacture of Anthracite Pig Iron.—During the year 1869 the production of anthracite pig iron in the United States amounted to 971,150 tons of 2,000 lbs., as follows :

	Tons.
Massachusetts	4,200
New York	210,855
New Jersey	54,201
Pennsylvania	692,739
Maryland	9,155
Total	971,150

The following statement shows the progress of this branch of manufacture since 1860 :

Year.	Production, in tons of 2,000 lbs.
1860	519,211
1861	409,229
1862	470,315
1863	577,638
1864	684,018
1865	479,558
1866	749,367
1867	798,638
1868	893,000
1869	971,150

—*Bulletin of Am. Iron and Steel Association.*

The following are the average prices, during the last ten years, for rails of best quality, in France, all accessory pieces supplied with them :

	Per ton		Per ton			U. S. Equivalent, gold.	
	Fr.	cts.	£.	s.	d.	$	cts.
1860	159	75	6	7	9	30	91
1861	161	50	6	9	2	31	26
1862	150	45	6	0	0	29	04
1863	149	20	5	19	0	28	80
1864	160	75	6	8	7	31	12
1865	161	80	6	9	5	31	32
1866	160	10	6	8	10	31	18
1867	156	70	6	5	4	30	33
1868	148	80	5	19	6	28	92
1869	158	25	6	6	7	30	60
Present price.	180	00	7	4	0	34	85

—*Bulletin of Am. Iron and Steel Association.*

Iron and Steel.—The invention of Mr. J. Player, Philadelphia, U. S. A., consists in first dividing the cast-iron in the condition in which it is left by the smelting operation into small pieces, flakes, grains, or powder, by mechanical means, and then mixing it in a solid state, and in this minutely divided condition, with the oxides or other ingredients or agents designed to improve or purify it, or to aid in its conversion into steel or malleable iron, while such oxides or ingredients, or agents, are also in a solid state, and afterwards subjecting it to the puddling process or other manipulation intended to free it from its excess of carbon and from its impurities, so that in such manipulation the requisite mixture of the iron and purifying agents may be secured in the highest practicable degree. —*Mining Journal.*

The following is a statement of the export of rails from Great Britain during the month ended April 30, and the four months ended April 30,

1870, and the corresponding periods of the years 1868 and 1869; also, the quantity of pig iron exported to the United States during the same periods, compiled from official returns published by authority of the House of Commons:

COUNTRIES.	MONTH ENDED APRIL 30.		
	1868. Tons.*	1869. Tons.	1870. Tons.
AMERICA.			
United States	35,970	37,592	41,457
British	4,416	5,326	6,015
Cuba	572	....	1,219
Brazil	731	....	319
Chili	11	....	405
Peru	6	1,444	....
EUROPE.			
Russia	2,261	23,705	23,093
Sweden	171	3,225	....
Prussia	2,223	91	5,379
Illyria, Croatia, and Dalmatia	174	2,133	2,672
France	3	1,330	11
Holland	2,538	1,056	3,630
Spain and Canaries	2,209	3,050	1,249
ASIA.			
British India	8,978	7,299	17,894
Australia	789	1,663	1,008
AFRICA.			
Egypt	972	345	210
OTHER COUNTRIES.	3,944	7,109	3,913
Total	65,968	95,378	108,474
Pig Iron to U. S.	9,475	19,149	7,416

COUNTRIES.	FOUR MONTHS ENDED APRIL 30.		
	1868. Tons.	1869. Tons.	1870. Tons.
AMERICA.			
United States	98,993	129,996	131,831
British	5,802	9,187	9,748
Cuba	1,222	357	1,807
Brazil	2,017	603	2.164
Chili	304	1.857	6 388
Peru	105	9,430	3,283
EUROPE.			
Russia	2,485	33,145	27,692
Sweden	182	3,225	....
Prussia	2,223	1,389	12,793
Illyria, Croatia, and Dalmatia	4,269	12,432	15,200
France	15	2,559	163
Holland	12,401	3,691	8,103
Spain and Canaries	3,974	4,917	8,207
ASIA.			
British India	39,377	20,613	82,522
Australia	3,837	7,954	4,947
AFRICA			
Egypt	11,772	2,425	1,703
OTHER COUNTRIES.	11,520	17,659	26,091
Total	200,499	261,439	342,642
Pig Iron to U. S.	16,046	48,013	31,681

* Tons in all cases 2,000 lbs.

PATENT FOR A COLD TINNING PROCESS.—M. Daubie, iron-master, Blanc Murger Works, at Bellefontaine, in the Vosges, obtained in November last a patent for tinning by a cold process, in order to prevent oxidation of iron in general, and especially of iron wire, employed in the fabrication of cards and wire cloth, without altering its polish or rigidity. An addition to the patent was made on the 30th December. The inventor's chief object is to prevent the softening of the metal, and the mode adopted is successive immersion in baths containing cold solutions of salts of tin, with the addition of a certain amount of organic matter, such as fecula or starch, which has always been found valuable both in tinning and galvanization. The solution patented is composed as follows:—To every twenty gallons of water add 6 lbs. of rye flour, and let it boil for about half an hour; filter it, and afterwards add 112 lbs. of pyrophosphate of soda, 34 lbs. of crystallized salt of tin, 134 lbs. of neutral protochloride of tin, and from 3 oz. to 4 oz. of sulphuric acid. When the salts are dissolved the solution is distributed in eight or ten wooden vats, a little additional water being added to the first two or three of the vats. The wire is passed successively through the whole of the vats, and if great brilliancy of surface is required, also through draw plates at intervals, and the wire, while retaining all its rigidity, becomes covered with a brilliantly-polished coat of tin. Beautiful and inoxidizable cards and wire cloth have been produced by this process, which is applicable to wire for a hundred different purposes. M. Daubie, we are told, has also succeeded in silvering iron wire, by using, in place of the salts of tin in the solution, cyanide of silver and cyanide of potassium.—*The Engineer.*

IRON AND STEEL.—The invention of Mr. Charles W. Siemens, of Great George street, consists of an improved mode of introducing the reduced ore into the open hearth of the melting furnace without, on the one hand, exposing the reduced ore to the oxidizing action of the flame, and, on the other hand, without exposing the reducing hoppers, retorts, or muffles to the extreme heat of the smelting furnace. For this purpose the inventor does not discharge the reduced ore directly into the melting furnace, as heretofore, but into a chamber or chambers arranged at the back or along the sides of the same, in which chamber or chambers a reducing atmosphere is maintained by an influx of reduction gases, although there exists an open communication between the chamber and the furnace. The bottom surface of the chamber inclines towards the hearth of the melting furnace upon which the metallic bath is prepared, in order to facilitate the introduction of the reduced ore into the bath, when required, by means of rabbles introduced through a door or doors opposite the melting chamber. From this reduced ore chamber or chambers vertical or inclined hoppers or retorts rise upwards, into which the raw or calcined ore, together with the reducing and fluxing materials, are charged from above, by preference in a heated condition, and around these hoppers or retorts channels are provided, through which flame is made to circulate.—*Mining Journal.*

A REMARKABLE instance of the crystallization of metallic iron was noticed recently during an examination by Mr. Crookes of the Heaton or nitrate of soda process for the production of refined

iron. After the subsidence of the violent action which ensues when the nitrate of soda is in contact with the molten metal, the converter, or lower portion of the apparatus, is detached, and after a few minutes, the contents are turned out upon the floor in the form of a porous mass, weighing nearly three-fourths of a ton. A careful inspection of this mass of somewhat refined iron showed it to consist of minute cubical crystals, segregating or arranging themselves in feather-like groups. The crystals are said to be sharp and well-defined, and to present an exceedingly beautiful appearance. Such phenomena are by no means uncommon on the gradual cooling of masses of other metals, but the instances in which they have been noticed with regard to iron are very rare. During a recent visit to the smelting works of a mine in Wythe county, Virginia, we were able to procure exceedingly well-defined and quite large cubes of metallic lead, while the production of crystals of bismuth and some other metals, by a method of slow cooling, is described in most works on chemistry.—*American Exchange and Review.*

IRON AND STEEL.—By the invention of Messrs. P. R. Hodge, Adam street, Adelphi, C. Hengst, Fulham road, and N. Wilson, Holborn, they prefer to use, and claim as new, a flux composed of calcined borax (say), 1 oz., combined with essential oil of rosemary, or any of the essential oils, mixed with iron filings or iron powder, made very fine and mixed uniformly with the calcined borax and essential oil. This compound is put on the surface of the materials to be combined together, after being heated to about 240 deg. to 260 deg. Fahr., and then heated up in a close muffle or hollow fire, or a close heating furnace to a red heat.

TRANSFORMATION OF CAST IRON.—"Transformation of cast iron, wrought iron, and steel by means of the vapors of alkaline metals." Such is the title of a patent taken in France by MM. Charles Girard and Jules Poulain (date 17th August, 1869, No. 86,784), the particulars of which we extract from our excellent contemporary, the "Moniteur Scientifique":—

"In order to cause the vapors of sodium and potassium to act on cast iron in fusion, we heat one of the former metals in an iron retort to 392 deg. or 482 deg. under a pressure of five or six atmospheres. When this heat is reached we direct the vapor thus obtained into the heart of the iron in fusion; the mass swells, and an alloy of the iron is the result. These alloys, although very hard, are malleable, and may be forged and welded. They oxidize rapidly in air or water, and are easily decomposed if a current of air, steam, or carbonic oxide, is injected into them when in fusion. By these compound effects of the vapor of sodium and of air, for example, the whole of the metalloids in the iron are attacked, and the final result is pure wrought iron that can be hammered and welded with ease. Under certain circumstances the metal resulting from the operation may present the properties of steel. Finally, to facilitate the production of the metallic vapors, carburets rich in hydrogen may be added to the sodium or potassium in the retort.

"In place of sodium or potassium an alloy of the two may be used, as, for instance, one composed of 4 parts of potassium (melting at 122 deg.) and 2.5 parts of sodium (melting at 194 deg.). This mixture, which has the appearance and consistency of mercury, has its point of solidification at 47.4 deg., and is consequently liquid at ordinary temperatures. It is prepared under naphtha.

"It has been remarked that, besides the direct transformation of cast into wrought iron or steel, by means of the metals, their action produces other advantages; they allow of the employment of cast iron, which, although containing manganese, are reputed as bad, and cannot be converted by the Bessemer process, on account of the quantity of carbon, sulphur, or phosphorus which they contain. It is, in fact, now proved that the Bessemer process, far from eliminating the sulphur and phosphorus, tends rather to augment the proportion of these metalloids.

"The cast irons known as *chaudes*, and which contain silicium and magnesium, owe a part of their superiority to the calorific power of the silicium (7,800), the produce of the oxidation of which, silica, requires but little heat to disengage it, so that the liquefaction becomes more complete. On the other hand, carbon, under the same conditions, gives rise to the disengagement of masses of sparks produced by the gases, carbonic acid and carbonic oxide, which traverse the mass; these take from the molten matter a considerable quantity of caloric, and thus are unfavorable to liquefaction.

"In our process this latter inconvenience is partly dispelled, for the gases produced by the combustion of the carbon, sulphur, and phosphorus, combine with the soda or potash, and are mechanically carried through the mass of metal by the oxidation of the sodium or potassium.

"The direct action of the sodium or potassium, in the form of vapor, on the melted iron may be replaced by adding to the mixture of ore, fuel, and flux, either chloride of sodium, carbonate of soda, a corresponding salt of potash, or a mixture of these. Acting thus on any given ore, and using coke or coal as fuel, a result analogous to that obtained with charcoal under the ordinary system is obtained. We must add, however, that in the former case the current of hot or cold air should be longer maintained than when charcoal is used; this prolonged application of hot or cold air in the blast furnace may present inconvenience, which may be avoided by directing the alloys of cast iron with sodium or potassium into a converter, in which they may undergo the final action of the current of air; with this process the working of the blast furnace is the same as in ordinary cases.

"We arrive practically at an assimilation of the coke or coal with alkaline salts corresponding to those furnished by wood charcoal, either by watering the fuel with the alkaline solutions above-mentioned, and then allowing it to dry in sheds by introducing the salts into the mass of molten iron, or, lastly, by pouring a concentrated solution of the various salts on the fuel or the ore at the moment of charging the furnace.

"We intend to continue our experiments on the alloys and combinations of sodium and potassium with most of the other metals."

EXPERIMENTS, instituted with a view to the dephosphorization of the iron from the Königshutte furnaces (Prussia), were made by the introduction of chloride of calcium into the blast furnace, on the theory that chloride of phosphorus might thereby be formed and volatilized. It was, however, found that the chlorine was liberated

from its combination at entirely too low a temperature to effect any change. The results in this country, where fluoride of calcium has been substituted for the chloride, have been much more encouraging, and a decrease in the amount of phosphorus has really been effected thereby, some of it probably passing off in the form of a fluoride. The Prussian iron above alluded to contains 0.497 per cent. of phosphorus, and produces a highly cold-short and brittle Bessemer steel. Refining in a reverberatory furnace by means of jets of air forced down upon the surface of the iron was tried, but led to no favorable result. On puddling the iron and reconverting to cast-iron in a cupola, the percentage of phosphorus was reduced to 0.1. But this reconverted iron was found to be dearer than Cumberland iron delivered at the Bessemer steel works in Silesia, and so this process was abandoned of a necessity. It was also found that iron, when treated in this manner, loses silicon, thereby unfitting it for conversion into Bessemer steel.—*The American Exchange and Review.*

Annealing Pots.—Mr. G. Rose, of Birmingham, makes in the arch or roof of the fire-place or furnace in which the combustion of the fuel takes place, a series of nearly vertical flues. These flues are of a curved figure, and open at top into the annular flue or chamber in which the annealing pot is built or situated, and conduct the flame and products of combustion thereto. Horizontal flues are made in the brickwork of the annealing chamber or furnace, their inner ends opening into the curved or nearly vertical flues passing from the fireplace. The outer ends of the horizontal flues are open to the atmosphere, the amount of air passing through the said flues being regulated by sliding dampers or perforated plates, or perforated slabs. The front of the fire-place is closed by a door perforated with a series of small holes.—*Mining Journal.*

A discovery of extreme importance from a technical and commercial point of view, as well as of great interest to pure science, is that of the recently announced electro-deposition of iron. The iron thus deposited is of great beauty, has a beautiful lustre and a silky texture. No exact experiments have as yet been made on its tensile strength or conductivity. Faithful copies of examples of medieval art of extreme intricacy have already been produced by this means, the moulds used being of gutta-percha, or, in fact, of any material commonly used by the electro-metallurgist for such purposes. The process has also been applied to the production of stereotypes and to a number of other purposes. The material used to furnish the iron is a dilute solution of the double sulphate of the protoxide with the sulphate of potassa, soda, or magnesia, and the apparatus, a battery of low power, usually two small Smee's elements. To Dr. Jacobi, one of the earliest workers in the now fully-cultivated field of electro-metallurgy, we are indebted for this discovery, and the learned experimentalist has already exhibited many beautiful specimens of his art, besides announcing some curious properties possessed by the iron, among which may be mentioned its power of occluding fully twenty times its volume of hydrogen gas. If we accept the very just and well-founded opinion of the late Prof. Graham, that hydrogen is in reality *a gaseous metal*, may not this new form of iron be but an alloy of iron and hydrogenium?—*American Exchange and Review.*

Steel Rails.—A point of some interest has arisen in connection with the use of steel rails on the Great Central Belgian Railway. It is found that steel rails which have been laid resist wear and tear extremely well, but that they acquire such a polish that the action of brakes and the adhesion of engines upon them are seriously interfered with. Experiments upon the subject are being made with a view to the collection of further facts.—*The Engineer.*

Puddling Furnaces.—Mr. J. Halford, Kingswinford, constructs an oven, or combustion chamber, similar in its general form and size to the chamber of the ordinary fire-places; but he makes the bottom of the oven or chamber without fire-bars or other opening for the air, and upon the bottom the fuel to be burnt is supported. The fuel is supplied to the oven or chamber by a hopper at the top, or by an opening at or near the side of the oven. The air for supporting the combustion of the fuel is introduced at an opening in front of the oven or chamber, this opening being at the lower part of the chamber. The fuel is always maintained at such a height as to cover the opening at which the air enters. The whole of the air entering the chamber is thus made to pass through the ignited fuel.

RAILWAY NOTES.

The Fairlie Engine.—A new series of experiments designed to test the powers of the Fairlie Double Bogie Engine, were tried recently upon the first section of the 23½ in gauge Festiniog Railway. An engine of the ordinary construction, but of very small proportions, was tried in competition with the double bogie "Little Wonder." This engine, the "Welsh Pony," made by Messrs. England & Co., had been put into the "stable," and thoroughly overhauled and repaired in anticipation of the trial. The first experiment was intended to show the comparative steadiness and smoothness of motion of the two kinds of engines. The visitors took successively short trips upon the engines. The opinion, in so far as we could ascertain it, was uniformly and strongly expressed in favor of the "Little Wonder." The movement of the "Pony" was, we speak from our own sensations, a succession of hammerings upon the rails, whereas the two bogies enabled the "Little Wonder" to pass as steadily and smoothly round the sharpest curves as in the straightest runs.

The next test was to show the comparative power of the two engines. The "Pony" was yoked to a train of seventy-seven trucks, filled with slates, and weighing in the gross 194 tons. The load was hauled along the embankment at a moderate speed, and for a short distance up the rising gradient on the other side; but at the commencement, or near it, of a gradient of 1 in 90 the "Pony" was dead beat, and the train was backed to the starting point. The engine had next a train of forty trucks attached, but it was found that these could not be taken up the incline, and nine trucks were taken off. The "Welsh Pony" was able to haul the thirty-one loaded trucks satisfactorily. The "Little Wonder" then undertook the test,

and was attached to the same seventy-seven loaded trucks. It whisked them along the embankment and up the inclines with scarcely a check in the speed. The superior merits of the Fairlie engine were on this point also fully admitted. The "Little Wonder" then took up from Portmadoc to Festiniog a train of 125 trucks, seven passenger carriages, and a boat carriage. The train was 380 yards long, and the weight hauled was 114 tons 14 cwt. The distance, just under 14 miles, with a rise of 700 ft., was accomplished in 1 hour 17½ minutes. Deducting the time of four stoppages, the net running time was under the hour. In some places, between stations, the speed was over thirty miles an hour.

The series of experiments was perfectly successful as regards the merits of Mr. Fairlie's engine, and we have no doubt that the inspection, and the impressions received from it, will do much to encourage the adoption of narrow gauge lines and the Fairlie engine.—*Railway News.*

A Railroad in Greece.—The United States Consul at the Piræus, Greece, is writing to the "College Courant" a series of letters about Athens. Among the passages which sound oddly to the classical student, from the sharp contrast they present between the ancient and modern city, is the description of a trip by rail from Athens to the harbor. The road is only six miles long, and, though nowise extraordinary, it is a source of never-ceasing wonder to the natives. When it was first opened, the Archbishop was present, and consecrated the locomotive and each car by sprinkling them with holy water. Still the average Greek can not quite reconcile himself to it as any thing in the ordinary course of nature, and when he takes passage he does not cease to cross himself until the motion has become familiar. Every day large crowds of countrymen flock to the depot, and gather on a bridge near by, to watch the train arrive and depart. Could some of their ancestors, who hewed the stone with which the track is laid, revisit their work, or look down upon it from the Acropolis, with what unutterable amazement would they contemplate the approach of a screaming locomotive, without even the poor protective of holy water! Accustomed as they were to the apparitions of gods, demigods, and monsters, this would be a spectacle for which even their mythology could furnish no parallel, and would dumbfound the wise as well as the ignorant. Think of Socrates soliloquizing over a steam engine, Diogenes, with his tub, dead-heading it to the Piræus, or haggling about a seven-cent ticket, or Euripides working up a railroad catastrophe into one of his polished tragedies, or the courtly Xenophon taking topographical notes for his "Anabasis" from the window of a Pullman sleeping car! These unsophisticated old Greeks, whom we imagine we understand fully, lived in an entirely different world, with which we can have but little sympathy. *Shall some future generation say the same of us?—Iron Age.*

Swing-Beam for Freight-Car Trucks.—That all railway stock should be so constructed as to run with the minimum of concussion between the board and the rail, is conceded by all except the extremely old-fashioned managers, who will not accept any of the the "new-fangled notions," such as safety switches, steel tyres, steel rails, homogeneous boiler plates, etc. It seems that some of the Southern railway managers have got a little ahead of their neighbors in constructing their freight cars with the swing-beam truck, and refuse to allow others of the old-fashioned type run over their roads. In the report of Mr. Fleming, the superintendent of the Mobile and Ohio Railway this matter is thus referred to :—

"As some objections have been raised by connecting roads who wish to exchange freight cars, as to the policy of this company, which refuses to permit any but swinging beam cars to run on the road, the following extract is made from the annual report of 1867:

"'The *truck* is one of the peculiar characteristics of American railways, and, with a few exceptions, is not used in other countries. Its invention was the legitimate result of the imperfection of American tracks, and it was designed to permit the wheels to adapt themselves to the sinuosities of the track, while the line of traction would conform to the general direction of the rails. The importance of these principles is so well recognized that, *without exception, all passenger cars* are constructed practically "centre bearing," and the bodies suspended on the trucks, allowing them to vibrate freely, and the wheels to follow the irregularities of the track.

"'Although these principles are so well recognized as indispensable to safety of passenger cars, they are not generally applied to freight cars, except upon Southern roads. Of the connecting roads who use the swinging-centre trucks, are the New Orleans, Jackson and Great Northern, the Mississippi Central, Vicksburg and Meridian, Selma and Meridian, Illinois Central, and Louisville and Nashville. The experience of this company during the war—when cars from almost every Southern road and of almost every pattern were used—justifies the refusal to permit rigid trucks to be run on the road, even if the plainest principles of mechanics and common sense did not demonstrate the greater safety of the swinging-beam truck."—*American Railway Times.*

Knowles's Permanent Way.—We are informed that some portions of the line near Stourbridge which have been laid with the permanent way invented by Mr. Knowles, and which have been subject to severe pressure from the shunting of trains, have given very satisfactory results, and that, as compared with the adjoining timber-sleepered portions of the road, they have been much less influenced by the changes of temperature. In the system of Mr. Knowles wooden sleepers are altogether discarded, and are replaced by nearly square plates of rolled iron, which do not cross the line, so that the near and the off rail remain separate as regards their foundations, and are only united by tie-rods to preserve the gauge. The sleeper plates are 18 in. by 16 in., and are concave beneath from side to side, with bent down edges, convex above, and traversed on the upper surface by a broad groove, with overhanging margins. This groove receives and secures wrought iron jaws or clips, which serve as substitutes for the covered chairs; and the clips are of such size and shape that, when they are pressed closely against a reversible rail, it is suspended between them by its top tables resting on their upper edges, and having no direct bearing on the sleeper beneath. The sleepers are placed opposite to one another, and the tie-rods already mentioned pass through the rails and clips, and

are screwed up by nuts on both sides, so as at once to close the clips firmly and to maintain the gauge of the line. Where there is no joint a single tie-rod suffices between two opposite sleepers; but every joint is placed over the middle of a sleeper, and has a tie-rod on either side of it, besides two extra bolts. The ordinary clips are 6 in. in length; but those at a joint are 16 in. The leepers, clips, tie-rod, and indeed everything but the top of the rail, is intended to be covered by ballast, and the sleepers would then lie at a depth of about 5 in. from the surface. The merits claimed for this system are, that at a very slightly enhanced original cost it confers greatly increased durability; and, in the second place, that it will give a steadiness of motion that will be conducive both to the comfort of passengers and to the preservation of springs, wheels, and axles—points which it is scarcely necessary to say are of considerable importance in the economical working of our railways.

The directors of the Great Indian Peninsula Railway Company, in their report for the half-year ending the 31st of December last, congratulate the proprietors upon the recent completion, and opening for public traffic, of the main line of this company's railway to Jubbulpoor, whereby through communication by means of the Great Indian Peninsula and the East Indian railways is now established between Bombay and Calcutta, and also with the North West of India. The connection of the Great Indian Peninsula with the East Indian Railway at Jubbulpoor was effected on Monday, the 7th of March last. The detailed estimates of sanctioned works, of unsanctioned works considered necessary and contemplated works, show that to complete the Great Indian Peninsula Railway, 1,272¾ miles in length, with the requisite stations, workshops, and rolling stock (322 miles being double line), the share capital of the Company will require to be increased from the present amount of £17,000,000 to £20,000,000. The capital account to the 31st of December, 1869, showed that £18,700,337 had been expended, leaving a balance of £2,631,774.

New Locomotive.—A correspondent of the "Locomotive Engineers' Journal" describes as follows a locomotive built in the shops of the Louisville & Nashville Railroad, at Louisville, and designed by Mr. Thatcher Perkins, the Master of Machinery of that road:

"The principal feature that strikes the eye at first sight, is the distribution of weight on the drivers, the forward pair coming so far forward that they lap in behind the guides, the yoke or plate holding the guides attaching near the middle. The entire engine, frame, cylinders, rockers, and in fact all the work is much heavier than usual. Mr. Perkins has the past year added largely to the facilities of the shops (which are very extensive) by the purchase and erection of a large amount of improved machinery, and has now in course of construction six new engines for the use of this road.

Changeable Gauge Cars.—The San Francisco "Bulletin" of the 20th ult. announces as follows the success of the experiment made by the Erie Railway in sending a loaded car of changeable gauge through from New York to San Francisco:

"The first through freight car from New York to this city arrived Saturday evening, and was unloaded to-day at the foot of Second street. It is the result of an experiment by Fisk, who intended, if it proved successful, to have a large supply of freight cars constructed on the plan of this one for the transit from ocean to ocean. The feature of the car now here is, that it is mounted on axles on which the wheels can be moved to fit any desired gauge of track. In all devices heretofore used for changing gauge, grooves have been cut around the axle according to the number of changes to be made. It is claimed that these notches destroy the strength of the outside fibres of iron and weaken the axle. The device in this car obviates this difficulty, by inserting a stout feather key laterally on the axle, which secures the wheel at any point on the axle. It extends into the axle about ⅜ of an inch. The inventor of the patent is W. B. Snow, who came on the car. It was built by the Erie Railroad Company, and was freighted with boots and shoes, from Philadelphia, consigned to Hobart & Co., of this city. The trip was made without accident of any kind, and the experiment was pronounced successful. It is stated that the Erie Company will build 1,000 cars for this through trade. The trip was made in 14½ days from New York."—*Railroad Gazette.*

Supplying Locomotives with Water.—The plan of supplying a locomotive with water while in rapid motion, is applied on the Hudson River Railroad, near Peekskill. In carrying this method into practice the company have provided between the rails of the track an open tank or trough, 1,200 ft. long, 18 in. wide, 15 deep, and holding 16,000 gallons of water, supplied from two adjacent springs. The tender is furnished with a pipe having a nozzle pointing forward, and capable, through simple mechanical appliances, of being readily raised and lowered. The train running at full speed (in the first trial of the apparatus it ran at 35 miles an hour), the nozzle is let down so as to pass 2 inches below the surface of water in the trough. As a consequence, the water is forced through the nozzle into the pipe and thence to the tender. The system works so well that a similar apparatus is to be located between Catskill and Hudson on the same line, and it is proposed to establish others at various points between New York and Chicago, which is expected to materially reduce the time required for the trip between the two cities.

This method has been in use in England, where it is known as Ramsbottom's method, but we learn from the "American Artisan" that the inventor was a Mr. McDonald, of Virginia, whose Letters Patent were granted in 1854.

State Railways in India.—Preparations are at last fairly on foot for surveying and staking out the route for the Mhow and Indore Railway, Mr. Crawford Campbell, C. E., "Superintending Engineer for the Indore and Mhow Railway," having already fixed the point of its commencement by a junction with the Great Indian Peninsula Railway, near Khundwa. The first engineering question of interest connected with the line is as to the place and method of crossing the Nerbudda; but we believe that Mr. Campbell at present expects to find the existing route by the Burwai pass suit him the best, though the gradients of the Simrole Ghaut may require some

special locomotive appliances to work them. The viaduct over the Nerbudda, though of considerable length, will not need to be of great height, as the river there only rises 25 feet. As it is very desirable the line should be as serviceable as possible to the important but now isolated station of Mhow, the route will probably be kept rather more to the westward after passing the Nerbudda, than would have been needful merely in aiming at Indore. After leaving Indore the line is to sweep to the west somewhat, so as to take in the important durbar centres of Rutlam, Jowra, and Mundesor. There will be several ordinary engineering difficulties to be encountered between the junction with the Great Indian Peninsula Railway and H. H. Holkar's capital; but beyond that first terminus, if the line should be carried forward to Neemuch, the work can be accomplished with tolerable facility, the country being level and the watercourses infrequent, though these include the Chumbla and Chumbul. There may be time enough to talk of going on to Neemuch, but this object seems to be a settled purpose with the present Bengali protectors of the Indore line. It is, of course, very important to have that military station and the centre of Rajpootana in direct connection by rail with other military stations on the south or west, and the Bombay merchant will be glad to have railway access thither by way of Malwa rather than be still excluded for an indefinite period.—*Times of India.*

The directors of the Mexican Company state in their report that Mr. Buchanan, their chief engineer, being now in this country, is carefully considering the advantages of Mr. Fairlie's system of engines with a view of determining how far its application may be desirable in the prosecution of the works remaining to be completed.

The Knox and Lincoln Company are to have their track laid from Bath to Damariscotta, and cars running next autumn. A large, substantial and powerful steamer is being built at Bath for their road, to ferry freight and passengers across the Kennebec river at Bath There are to be seven trestle bridges from Bath to Rockland. At Wiscasset there are 66,500 ft. of piling in 4,000 piles for bridges.

We are informed that a Manchester firm have received an order for some locomotives for a branch railway which is being constructed from the Yeletez and Orel line to Liwny. The locomotives will be on the Fairlie system, with twelve wheels. An English firm will also supply the rails required for the branch, but the carriages and trucks are to be made at Brussels.—*Manchester Examiner.*

Since the opening of the railroad to the Pacific, the price of Panama Railroad stock has fallen from 282 to 140, and its dividends have been reduced from 24 per cent. gold, to 16 per cent. currency.

Great progress is being made with the Punjaub State Railway. Three great iron bridges are to be thrown over the Ranee, the Chenab, and the Thelum, and the iron work is to be ordered in England.

The construction of a southern trunk line is expected to be shortly commenced in the province of Otago, New Zealand. A contract has also been let for the construction of a line between Dunedin and Port Chalmers, in the same province.

ORDNANCE AND NAVAL NOTES.

Another New Gun.—The controversy between Sir Joseph Whitworth and Sir William Armstrong has, for a time, been allowed quietly to drop, and now we have ushered in a new piece of artillery to displace the inventions of both these gentlemen. The breech coil of this gun as it comes from the furnace will weigh 20 tons. The inner coil will be a bar 170 feet long, measuring 6 inches in depth, with a breadth on the upper surface of 5 inches. The magnitude of the operation may be apprehended from the fact that the length of this bar is very nearly equal to the height of the Monument. The coiling up of such a bar while in a state of red heat is a process well calculated to astonish those who are not familiar with such undertakings. The trunnion-hoop will be the largest solid forging ever made. As much as twenty tons of iron will be gathered round the "porter-bar," by which the forging is handled. This quantity of iron will be gradually accumulated, and finally worked *en masse*, the coherence of the whole being secured by the blows of the 15-ton double-acting Nasmyth steam hammer. A trunnion-hoop is, necessarily, a "punched" forging. It is, first of all, made solid, and then, by patience and perseverance, a hole is punched clean through the centre, corresponding in size to the body of the gun. When finally reduced to its proper shape and size by the excision of superfluous metal, the weight of this part of the gun will be 15 tons. In this state it will be a rough forging, and the subsequent process of "turning," by means of gigantic lathes, will reduce it still more. It was intended that the 30-ton gun should only be of 12 inches calibre, and we see that the 35-ton gun itself will go no farther than this, but will probably stop short at $11\frac{1}{2}$ inches. The gun now making at Woolwich is a considerable step in the right direction; but although we go from 25 tons to 35, we are yet far within the limits of our strength.

There is in course of erection, on the east side of New York Bay, a gun that will throw 800 five-ounce balls in one minute to a distance of about two miles. The shot may either be red hot or cold. The gun is circular, and appears like two discs of heavy iron plate about four feet in diameter; upon one side is a funnel to convey the balls through to the proper chamber without cessation of firing or diminution of speed; the muzzle projects upon the periphery of the circular machine, and may be elevated or depressed at the will of the gunner by the trunnion on which it rotates. The machine may be worked by manual labor or steam power, and when worked by the latter it will throw from five-ounce balls to eight pound shot and shell, thus making it a very destructive improvement of warfare. The construction of the gun is under the care of Robert McCarthy & Son, and it was expected that it would be finished in time to test it by July 4.

(We find the above paragraph floating about among the daily and weekly papers. We trust our readers will recognize this dear old gun. The slight modification in detail as given above is not enough to disguise its more important and familiar features. As a revolver among the journals it has failed somewhat of late in frequency and regularity of appearance. During the first years of the war it came around once a quarter.

It will be observed that the old statement, that it could be worked with ease by two men, is omitted in the above description. This, at all events, indicates *some* progress.—Ed.)

The steamship Edinburgh has recently been fitted with compound engines of 275 nominal horse-power, by Laird Brothers, Birkenhead, for the service of the Telegraph Construction and Maintenance Company. Her dimensions are 290 ft. long, 39 ft. wide, and 26 ft. deep; tonnage, 2,200 tons. She is now arranged with three large cable tanks, two of them being 32 ft. in diameter by 22 ft. deep, and the third 26 ft. in diameter by 20 ft. deep. Under the two largest of them there has been fitted an inner skin, forming a double bottom for stowage of water ballast when the weight in the cable tanks has run out. There are also various other fittings and appliances specially arranged for the telegraph work. The engines, which are new, have been made by Messrs. Laird on the compound system, and are the third pair made for the same owners. The Edinburgh's engines are vertical, the small cylinder having a diameter of 44 in., and the large cylinder 78 in., with a stroke of 3 ft. 6 in., and are nominally of 275 horse power. The cylinders are jacketed at the tops and bottoms as well as the sides. The valve for admitting the steam to the small cylinder is fitted with an expansion valve, and is placed at the forward end, and the valve for admitting the steam into the large cylinder is placed between the two cylinders. The pumps are worked by levers from a crosshead on the piston rod of the large cylinder. The condensers have horizontal tubes, the water circulating inside the tubes. There are two cylindrical boilers, firing from both ends, having two furnaces each, with return tubes, and fitted with cylindrical superheaters on the top of each boiler. On the first voyage just completed by this ship from London to Malta, with the cable to be laid from that port to Gibraltar on board, the following results were obtained:—Draught of water forward, 24 ft. 3 in.; draught of water aft, 22 ft. 3 in.; mean, 23 ft. 3 in.; displacement at ditto, 4,870 tons; average consumption per I. H. P. per hour, 1.70 lb.; number of knots per ton of coal, 13.7.

ENGINEERING STRUCTURES.

Opening of Connecticut River Railroad Bridge.—The New York and Boston Shore Line Railroad bridge over the Connecticut River was formally opened on June 11. The length of the bridge is 1,130 ft., and it cost about $225,000. The substructure consists of fourteen column piers to support the stationary spans, besides the abutments at the shore ends, and eleven column piers to support the turn-table and swing span. Each column pier is formed by driving a number of piles in close proximity, covering in the aggregate an area of 5 ft. square. The piles are firmly bolted together; iron cylinders, some 7 or 8 ft. in diameter, are then let down in sections over the piles so as to completely surround them, and the space between the cylinder and piles is filled up with concrete.

The stationary spans are constructed of wood and iron on the truss principle. With the exception of the flooring, which is of wood, the swing span is of wrought iron; it is built on the Pratt style, is 280 ft. long, and can be turned by two men. The bridge will bear a strain of 2,500 lbs. to the running foot; but the breaking weight is estimated at about five times the bearing strain. Although the weather was unfavorable, the opening ceremonies passed off very pleasantly.

The Darien Survey.—Report of Capt. Selfridge, Commandant of the Expedition.—Capt. Selfridge, commander of the Darien expedition, who arrived in New York with his flag-ship Nipsic, reported in person at the Navy department. He made a long verbal report of the results of the expedition to Secretary Robeson and Vice-Admiral Porter, and subsequently accompanied the Secretary to the White House, where he explained to the President and the members of the Cabinet the results of the different surveys, and the prospects for the success of the enterprise. The Caledonia and the Morti routes, both thoroughly surveyed by Capt. Selfridge and his party, are pronounced by him as impracticable. The San Blas route, he states, can be made successful. He had not got through with his survey of this latter route when the heavy rain season commenced, and he was compelled to abandon any further progress for the present. Beside this, the entire supplies for the expedition were exhausted. Over 600 pairs of shoes had been worn out by the men, with other clothing in proportion. This San Blas route includes 12 miles of the Bayamo River, which is 18 feet deep at low water, and 28 feet at high tide, with an excellent surrounding country, and also 26 miles of mountains or very high hills. There he was engaged in surveying when he was compelled to give up, on account of the rainy season, exhaustion of supplies, etc. He says there is no doubt but that the canal can be cut through this 26 miles from ocean to ocean, and that the only thing to be now considered is the cost. He says that if this Government feels too poor to undertake the work themselves, they should make a proposition to the great Powers of Europe, and make the canal an International enterprise, with guarantees from all the Powers for its preservation and safety, and each Government to bear equal portions of the expense. Capt. Selfridge's reports and explanations were highly complimented by the President, the Cabinet officers, and Admiral Porter. The President expressed himself much pleased with the results of the expedition so far, and stated that he would recommend to Congress further appropriations for the enterprise, and appeared to think that this country should do all the work itself, and take all the benefits. Capt. Selfridge was relieved from the command of the Nipsic, and ordered to Portland, to prepare for the renewal of the survey next Fall. The steamer Guard is on her way home to Philadelphia, and the steamer Nyack has gone to Panama. These, with the Nipsic, comprised the fleet. Capt. Selfridge states that he lost one man by drowning, and three by desertion, and that the general health of the fleet, officers and men, was excellent, considering the disagreeable rainy season.—*N. Y. Tribune.*

The New Pier at Cardiff.—The low-water pier recently completed at Cardiff was constructed by the trustees of the Marquis of Bute, Mr. J. MacConnochie being the engineer. It was commenced in August, 1867, and during the following year all the piles carrying the superstructure were driven. These piles are of Memel timber, placed 24 ft. apart, and with 6 piles transversely in each row. The total length of the pier is 1,350 ft., and its breadth 34 ft. 6 in., except at the head, where the width is increased to 100 ft. The roadway. 10 ft. above the level of spring tides, is carried upon wrought-iron girders, which extends from end to end of the pier in two rows. The roadway consists of planking, and a timber fence extends on both sides for the whole length of the pier, except at the landing stages, where chains are substituted. The platform is divided into a footpath for passengers and a space for vehicles, while a railway runs along the whole length to the pier head. The passenger landing stage is a pontoon 80 ft. long and 30 ft. wide, rising and falling with the tide, and connected with the pier by a flight of steps and landings at different levels. Over the pontoon is built a railway station 108 ft. long, and 20 ft. high, with waiting rooms and office, and immediately adjoining is a tower 40 ft. high carrying a dioptric light. Beyond the station, sidings to facilitate loading and unloading vessels, are laid, a traverser extending across the pier, for connecting the main line with the sidings. At the end is placed a 10-ton hydraulic crane worked from a large engine close to the East Dock basin. A lift also is provided for raising passengers or their luggage from vessels alongside.

At present the extension of the line from the pier connects only with the Rhymney Railway, and trains run through to the Adam street station, but other junctions will subsequently be made.

NEW BOOKS.

The Science of Building: an Elementary Treatise on the Principles of Construction especially adapted to the requirements of Architectural Students. By E. Wyndham Tarn, M.A., London, Architect. Illustrated with forty-seven wood engravings. London, Lockwood & Co. For sale by Van Nostrand.

Mr. Tarn has well described the scope of his work in his preface, where he says that he "has endeavored to introduce the student of architecture to a general outline of the scientific subjects connected with his profession, an acquaintance with which can at present only be obtained by the perusal of a large number of works by various authorities." He further states that in compiling his treatise, he "has been careful in all cases to consult the writers who stand highest in their respective branches of knowledge; and by avoiding the use of the higher mathematics, as well as those topics which belong more especially to the engineering profession, he has brought the various subjects within the capacity of those whose mathematical attainments do not extend beyond elementary geometry and algebra."

To say that Mr. Tarn has carried out the programme laid down in his preface would, however, be rendering him very scant justice. In reality his book is very far from being a mere compilation; it is an able digest of information which, as he truly remarks, is only to be found scattered through various works, and his book in fact contains more really original writing than many putting forth far stronger claims to originality.

The book commences with a comprehensive and clearly-written chapter on "Mechanical Principles," in which our author treats of the composition and resolution of forces, diagrams of forces, moments, centre of gravity, stability of walls, strains on beams, and other kindred matters. This is followed by a short chapter on "Retaining Walls" which is in its turn succeeded by one on semicircular, segmental, elliptic, Gothic, and oblique arches and cupolas. In this chapter Mr. Tarn has managed to deal with an abstruse subject with as little complication as possible, and, moreover, the somewhat lengthy formulæ, which have unavoidably been introduced here and there, are illustrated by examples which will materially assist their application by the student. We notice that in this chapter the author has given a digest of some interesting investigations of his own, relating to Gothic arches and vaulting and the stability of domes.

Leaving theory for a time, Mr. Tarn next treats of the materials employed in construction; and his fourth chapter is devoted to a description of the principal natural and artificial stones and their qualities. The fifth chapter deals with timber, commencing with some remarks on the growth of trees and the decay to which wood is liable, and passing on to consider the strength of different varieties of timber, the strength and deflection of wooden beams, the strength of pillars, the framing of roofs, and centrings for arches. Next we have a chapter on cast and wrought iron and steel, containing information relating to the strengths of cast-iron beams and columns, the strength and deflection of wrought-iron beams and girders, strains on roofs, etc.; the information afforded on these matters being just that which an architectural student requires.

The last chapter relates to data concerning water in vessels and pipes, such as rules for calculating the pressure on the sides of tanks, the flow of water through pipes, etc. Somewhat to our surprise, we came upon a paragraph in this chapter relating to specific gravity, and the mode of ascertaining it. At first we considered this paragraph out of place; but we must own that after looking over the book again we are unable to suggest a more suitable position for it; unless, indeed, it was placed in the appendix, which contains a lengthy table of the specific gravities and weights per cubic foot of all the principal materials used for building purposes.

Altogether, Mr. Tarn has done his work exceedingly well, and he has produced a book which ought to earn him the thanks of all architectural students. To the publishers, also, a word of praise is due. The book is clearly printed in bold type, the wood-cuts are all well executed, and the work has been made of a very convenient size for reference.—*Engineering.*

The Fuel of the Sun. By W. Matthieu Williams, F. C. S. London: Simpkin, Marshall & Co. For sale by Van Nostrand.

We have in the work before us a proof that a very interesting and readable volume may be produced, although the hypothesis which has called it into being may be one with which we do not agree. Mr. Williams discusses at greath length the very

perplexing question of the sun's fuel, nevertheless we do not think that his hypothesis is an improvement upon that of Helmholtz and Thomson. But let us hear the writer speak for himself. After having come to the conclusion that an atmosphere very similar to our own, but only more attenuated, pervades all space, he supposes that the sun, in its progress through space, encounters new portions of this atmosphere, and then asks the following question: "Does there exist in the actual arrangements of the solar system any machinery for stirring in an important quantity of the new atmospheric matter and ejecting the old? If so, the maintenance of the sun's heat may be fully accounted for." The question is answered in the affirmative; the atmosphere is supposed to be the sun's fuel, and the planetary attendants of the sun are supposed to perform the duty of stokers with untiring vigilance and efficiency. The mode of action of this atmospheric fuel in furnishing heat is supposed to be as follows: "It is evident, then, that the first result of the great evolution of heat from mechanical condensation of the mixed atmosphere of aqueous vapor, carbonic acid, and free oxygen and nitrogen, will be the dissociation of the water and the carbonic acid. But there must somewhere be a height at which the temperature capable of effecting dissociation terminates; where the atmosphere of elementary gases fringes upon that of combined aqueous vapor, and where these separated gases must revert into reunion with a furious chemical energy which will be manifested by violent combustion. Thus we shall have a sphere of dissociated gases and a sphere of compound vapors separated by an interlying stratum of combining gases, a spherical shell of flame, constituting exactly what solar observers have described as the 'photosphere.'" In fine, Mr. Williams' hypothsis is "a perpetual bombardment of 165 millions of millions of tons of matter per second without in any degree altering the density, the bulk, or any other element of the solar constitution."—*Nature.*

Einleitung in die Physik. Bearbeitet von Professoren G. Karsten, F. Harms, und G. Weyer.

The volume before us is introductory to the "Allgemeine Encyclopädie der Physik," which is in course of publication, under the general editorship of Professor Karsten. The authors endeavor to supply whatever would not naturally be found or expected in the separate treatises of which the Encyclopædia is made up, which have been written independently by specialist authors from their individual points of view. They add a systematic treatment of everything that may be considered auxiliary to the entire group of the physical sciences.

Professor Harms is the author of the most important part of the work—a philosophical and historical introduction to the whole subject. The discussion ranges over three principal heads:

1. What are the proper limits, and the true relations of physical science, and what distinctions can be drawn between it and the other sciences of matter?

2. What are the methods of physical inquiry, with a critical estimate of induction, of speculation or deduction, and of the theory of cognition (Erkenntniss-theorie) which has arisen in Germany since the days of Kant. This discussion is naturally conducted both historically and metaphysically. The rapid but exhaustive reviews of Bacon, Locke, Hume, Sir J. Herschel, Mill and Whewell—the only authors quoted on the subject of induction—will be specially interesting to English readers.

3. The philosophical basis of the conceptions at the root of the natural sciences, with a full treatment of Idealism and Materialism, and a discussion of the differences between matter passive and without force, and matter active, bound up, that is to say, with capacities of change of state.

Professor Karsten's contributions involve an enormous amount of statistical and bibliographical labor. Fifty pages are occupied with a complete catalogue of the literature of general physics. All the encyclopædias, all the scientific periodicals and collections, all the books on the history of science, and all the handbooks and general treatises of all modern nations, are gathered together in one most useful and naturally bewildering list. Germany, Switzerland, England, the United States, France, Belgium, Holland, Denmark, Sweden and Norway, Russia, Italy, Spain and Portugal, are the countries which contribute. The order in which we have given them exhibits the civilized world from the German professor's point of view.

A second treatise by the same author deals with all of what are called the universal properties of matter, and discusses in full the problems of chemical affinity and the newest theories of atoms. Little is really carried lower than the year 1860, but references are given to all books of importance published as late as 1867.

His third treatise gives us the methods of measurement, with full descriptions of the instruments and copious tables of comparison between the units of different countries. Professor G. Weyer finally supplies a separate work on the determinations of space and time. All questions of latitude and longitude, of apparent and real magnitude, are fully discussed, and the astronomical data which affect our estimates of time are exhibited in full.

We have preferred to give our readers a simple statement of what is contained in the closely-printed volume of 900 royal octavo pages before us. Detailed criticism of five separate treatises, in the space at our disposal, is a mere impossibility. It is sufficient to say here that every subject discussed is worked out in all the painstaking and exhaustive detail to which the separate volumes of Karsten's Encyclopädie previously published have accustomed us. Such works are of the greatest possible service to literature. They are not produced in England. Our scientific men are too busy conquering new worlds, and lecturing on the exciting incidents of every fresh conquest. There is not a man too many thus engaged, but we confess that we sometimes turn with desire to our two great mediæval universities, where the liberality of our forefathers has established hundreds of fellowships, expressly that men might have leisure to devote themselves to life-long studies. How is it that Oxford and Cambridge leave us to sigh for impossible translations of laborious books like this which has been sent us principally by the University of Kiel?—*Nature.*

The Slide Valve Practically Considered. By N. P. Burgh, Engineer. Third Edition. London: E. & F. N. Spon.

It is quite unnecessary for us to enlarge upon the important position which the slide valve occupies among steam-engine details, or to urge the

necessity which exists that all engineers engaged in steam-engine construction should thoroughly understand the action of such valves, and the effects attending variations in their dimensions. These matters being of acknowledged importance, it is but natural that we should be disposed to regard favorably any treatise professing to deal practically with the subject of the slide valve and its proportions; and we, therefore, commenced our examination of the work before us in the full hope of finding it a book which we could conscientiously recommend to engineering students, and, in fact, to all in want of information on the subject with which it deals. In this hope we were strengthened by the fact that the book had already reached a third edition, and by the statement made in the preface, that this third edition had been rewritten and extended. Much to our regret, however, we find the work to fall very far short of what we conceive that such a treatise should be, for although it probably contains but few actual misstatements, yet it is greatly wanting in that clearness and precision so pre-eminently requisite in a book dealing with the slide valve and its action. In fact, the impression left on our minds by a perusal of the work is not, perhaps, so much that Mr. Burgh is ignorant of the subject on which he writes, as simply that he entirely lacks the power of communicating his knowledge in clear and easily comprehensible language; while, moreover, he is far too much inclined to substitute descriptions of particular examples in the place of explanations of general principles capable of universal application.

Of locomotive practice Mr. Burgh says nothing, neither does he distinguish in any way between the proportions required for the valves of fast running as compared with slow running engines. A variety of other matters with which a treatise on the slide valve ought to deal are likewise left unnoticed, and altogether the work requires to be enlarged and, above all, entirely rewritten. At present it is little more than a prolonged enigma.—*Engineering.*

Marvels of Architecture, translated from the French of M. Lefèbre. To which is added a Chapter on English Architecture. By R. Donald. London: Cassell, Petter & Galpin. For sale by Van Nostrand.

This is a pretty little book, very readable and likely to interest many in what architecture has done. It is not intended for the professional student. The chapter on English architecture is the least satisfactory part of the volume, and further confirms what we recently said as to its being desirable that persons who write about buildings should know something of architecture. Take an instance in proof. The author is speaking of "the Gothic style of architecture which sprang into ascendency during the Middle Ages," and says:

"The style is also widely known as the *Pointed* style of architecture, and is very largely to be found in the *Saxon and Norman* edifices of this country. What is known as the *Corinthian order* of Pointed Architecture is, indeed, almost peculiar to England."

Very peculiar, indeed, we should say. Again:

"Though the Gothic and Pointed styles are often confounded, there is considerable distinction between them. In Gothic, the general running lines are horizontal, as in entablatures and single cornices; in Pointed, the general running lines are vertical."

The author is evidently at sea. Nevertheless, it is an interesting little book; and it includes a considerable number of illustrated wood-cuts.

Elements of Surveying and Levelling, with Description of Instruments and the Necessary Tables. By Charles Davies, LL.D. New York: Barnes & Co. For sale by Van Nostrand.

This new work is the result of a complete revision of the "Elements of Surveying and Navigation," by the same author, a work which has held for many years the foremost place among our text-books upon this branch of science.

Of late, however, there has been a demand in our higher schools for instruction of a more technical character, adapted to the wants of those pupils who designed to assume somewhat responsible positions in scientific pursuits.

This demand has been meagrely supplied, so far as the different branches of surveying is concerned, by Engineers' Table Books, which, although well designed for the wants of engineers in full practice in the field, were illy adapted to the use of the learner of the rudiments.

We find in this new work all that can be asked for in a text-book. The following synopsis of a few chapters will verify our statement:

In the trigonometrical examples in the first sections, regard has been paid to the problems most frequently occurring in ordinary practice, and the methods of solution are those which custom at least has sanctioned.

In plane surveying, the methods of holding the chain, chaining up hill sides, distributing the work in a full party, or a small one, keeping the notes, distributing the error of balances, are all set forth in the most satisfactory manner.

In railway curves, an outline of the different methods of calculating and locating the circular curves is given. Besides, the "deflection method" in general use, there are given the methods involving the use of the chain only, some three or four in number, and the method which requires two transits and no chain.

In section levelling, the methods of the railroad engineers are fully explained. The reconnaissance, the establishment of the route, the field operations, use of *benches and turning points*, taking and reducing the notes and establishing the grade-line, are treated each in proper order.

This is naturally followed by cross-section leveling; and in this chapter much useful instruction will be found which has never appeared in the books before. Twelve pages are devoted to the method of setting slope stakes. The diagrams are numerous, and all possible cases of excavation and embankment are covered by the method explained.

The rules for the field operations and recording the notes are given in italics. The leading methods of calculating the earthwork are each applied to an example.

The section on mining surveying ends the work. In this, as in the preceding chapters, the instruction is of a thoroughly practical kind; two or three excellent illustrations aid the text. If there is anything in the few works on sub-surveying as well adapted to the student's wants as this chapter, it has escaped our search for it.

There are other sections, which we have omitted, which deserve mention, but the above synopsis will give the reader a fair idea of the value of this new text-book in surveying.

Die Spectralanalyse in ihrer Anwendung auf die Stoffe der Erde und die Natur der Himmelskorper. Von Dr. H. Schellen. 1 vol. 8vo. Brunswick. 1870. For sale by D. Van Nostrand.

The author is director of the "Realschule" of Cologne, and has produced an admirable compilation, in which, with scientific sequence, everything of importance up to the present time on the nature, use, applications, and discoveries so far due to spectrum analysis, are given, along with a running commentary as to the history of the method itself, not forgetting those to whom it is chiefly indebted, even to the extent of giving some of their portraits. It is a very real and practical book, though so well illustrated with wood-cuts, two spectrum plates in color printing, and four portraits, as to have some pretensions to be claimed as a work *de luxe*. Spectrum analysis has no doubt already elicited marvellous results, and takes captive the imagination by the prospect it offers of questioning the stellar bodies and spaces far beyond all other as yet known means of chemical inquiry.

But although it is in the hands of men of far higher knowledge, and of exactive science, and, on the whole, of far soberer views than are the glacial geologists generally, there is some danger that this new Pegasus, when launched fairly out into the celestial spaces may run away with its riders. Some recent retractations of recently assumed discoveries by this method of new elements, even in things that we can reach and handle, ought to inspire a wholesome caution and reserve as to the things in heaven, as visible to spectral philosophers and in their methods.

Meteorology. By Sir John F. W. Herschel, Bart. From the Encyclopædia Britannica. Second Edition. Edinburgh : A. & C. Black.

Introductory Text-book of Physical Geography. By D. Page. Fourth edition. Edinburgh : W. Blackwood & Sons. For sale by Van Nostrand.

We class these two books together as new editions of standard treatises in their respective departments of science that are among the best that can be used by students or teachers. The term "Meterology," which has entirely lost its etymological meaning, is defined by Sir John Herschel as "the description and explanation of those phenomena which group themselves under the head of the weather, of the seasons, and of the climate,' a branch of natural science of the laws regulating which we are at present almost entirely ignorant, as Dr Balfour Stewart has shown in these pages. Writers on physical geography content themselves at present with a description of the physical contour of the globe, with some slight reference to its climatology, and the distribution of its animal and vegetable life, Mrs Somerville's handbook being, as far as we know, the most complete in this respect. The better and more logical mode would seem to us to be, first of all to treat of the earth as a member of the solar system, and thence to deduce the laws which govern its natural phenomena ; we believe that in this way such phenomena as those of ocean currents and trade winds, and the variations of climate, would be rendered far more quickly intelligible to the learner than is now the case. From his stand-point, Dr. Page's "Introductory Text-Book" discusses the subject in his usual clear, concise, and systematic manner.—*Nature.*

Rustic Adornments for Homes of Taste. By Shirley Hibberd. New Edition. London : Groombridge & Sons. For sale by Van Nostrand.

That two editions of this book have been disposed of in a short time is ample justification for the publication of a third, especially when got up in so handsome a style as the one before us. Works of this kind appeal to a large public, not over-critical as to scientific accuracy, but glad to possess that amount of knowledge which enables them to talk about ferneries and aquaria without committing any egregious blunder. We are far from depreciating the value of this smattering of science where it is all that opportunity permits to be attained. Those who like their homes to be surrounded by beautiful natural objects will here find a large fund of information respecting the aquarium, the fernery, the aviary, the apiary the conservatory, etc., given in a pleasant style, illustrated with wood-cuts and colored plates. The volume makes altogether a very pretty gift-book, especially for a young lady.

Other Worlds than Ours : The Plurality of Worlds Studied under the Light of Recent Scientific Researches. By Richard A. Proctor, B.A., F.R.A.S. Author of "Saturn and its System," etc. London : Longmans, Green & Co., Paternoster Row. For sale by Van Nostrand.

A new work from Mr. Proctor's pen is hailed by all interested in the science of astronomy. Mr. Proctor's subject is most interesting, and he has produced a very readable book, which will prove attractive alike to scientific and non-scientific readers. Speculations as to the conditions under which beings like ourselves would exist if inhabiting the planets, have often been brought forward ; and Mr. Proctor has here treated the matter in the same careful and exhaustive manner which characterized his work on "Saturn and its System." . . . We heartily recommend the perusal of this volume to every lover of the science of astronomy. Unlike many scientific works, a tone of reverence towards the Creator of all things runs through the book, which is greatly to be commended.—*Astronomical Register.*

Lecture Notes for Chemical Students. By Edward Frankland, F.R.S., Professor of Chemistry in the Royal School of Mines. Vol I., Inorganic Chemistry. Second Edition. London : Van Voorst. 1870. For sale by Van Nostrand.

We are glad to see that Dr. Frankland, in bringing out a new edition of his excellent "Notes," has divided the work into two parts, corresponding to the inorganic and organic divisions of the science. To the great mass of students this arrangement will be a boon. The alterations in the present edition are not numerous ; but such as they are we, must confess that they appear to us to be in the right direction. Notably would we point to the fact, that Crum Brown's graphic formulæ have been deprived of their circles, for it leads us to a hope that in the third edition they may be improved out of existence. We certainly, contrary to Dr. Frankland and other high authorities, deprecate the em-

ployment of the species of diagrammatic guess-work involved in the use of graphic formulæ. We believe that its influence over the student is as irresistible as it is pernicious, and we trust that ere long the development of a more positive school of chemistry may lead to its banishment from our books. Apart, altogether, from the fact that chemical bodies undergo their metamorphoses in a definite relation to certain figures which represent weight, we know nothing of atomic constitution, and such a thing as an atom is just as great an impossibility as the idea of a big wall limiting space and closing in the universe. Indeed, the dogmatism of certain chemists on this question reminds us of the curious archetype plans which some biologists would have us believe a creator set before him, lest he might make a mistake in cutting out the manifold patterns of animal life. Such things result from giving a false realism to mere dreamy and pleasant speculation; but they are out of keeping with true philosophy; and, with the help of a little more positivism, the study of phenomena will soon drive the graphic formulæ into the "curiosity shops" of chemical science.—*Scientific Opinion.*

MISCELLANEOUS.

UNION PACIFIC ENGINEERING.—The article in our June Magazine bearing the above title should have been credited to the "Chicago Railway Review" instead of the "Iron Age."

NEW METHOD OF RAPIDLY DRYING TIMBER.—What is required to be done in order to effectually dry timber? In the first place it is indispensable that all the soluble particles within its pores be removed, or otherwise it is manifest that they will always constitute a cause of dampness and deterioration. They would, in fact, act as a sponge, and absorb and retain a considerable proportion of humidity. By the method to which we draw attention, the soluble matters are first got rid of, and then the drying process thoroughly effected. The operation is commenced by allowing the timber to steep in boiling water for several hours, which removes all the soluble ingredients. At the lapse of this time it is dried, and again steeped or boiled in a weak solution of borax. The object of this is to remove the albuminous particles which will not dissolve out by the simple action of water, like the other more soluble ingredients. The action of the borax, however, produces this desirable result, and the albumen is then got rid of. The final step consists in removing it to a drying room heated by steam, where it remains during three days, at the termination of which it is perfectly dry. In France there are several large establishments for carrying on this drying business, and as the French employ more timber in permanent, or intended permanent buildings and erections, than ourselves, the workshops are kept generally very busy. It may be impossible to prevent the use of green timber, dating it from the time of felling, but it is not impossible to adopt some method of preparing it that shall prevent the wood of the floors, doors, and windows of houses two years old "gaping" in the face of their proprietors or tenants, as the case may be.—*The Building News.*

ECONOMIC PRODUCTION OF OXYGEN.—The production of oxygen on an economical system for industrial purposes, as well as for illumination, is a task upon which many chemists in France and elsewhere are engaged. M. Delaurier has given much attention to the manufacture of manganate of lime in connection with this subject. This manganate may be produced by heating together any of the oxides of manganese reduced to powder with an equivalent of slacked lime or chalk, also in powder, the two being carefully mixed together and heated to redness in contact with the air, the mixture being continually stirred or turned over, so that the absorption of the air may be complete. This composition is insoluble in water, it is formed much more easily than the manganate of soda and potassium from manganese and soda and caustic potash, because these manganates, being to a certain degree fusible, present smaller surfaces to the air for oxidation. The process indicated above has the advantage of furnishing at small cost a composition which serves in the production of oxygen for the oxyhydrogen light by the ordinary process, and also as a very powerful agent of oxidation in laboratory operations. The oxygen may also be obtained by the use of an equivalent of sulphuric acid which deposits the lime in the form of sulphate mixed with hydrated protoxide of manganese; two equivalents of oxygen are the result of this process. The manganate of lime is manufactured very economically by employing the salts of manganese, which are wasted in many industries.

TENACITY OF CAST IRON.—A Hanoverian engineer, Mr. Hagen, has given his attention to the loss of tenacity in iron castings caused by inequality in cooling, and the following are the results at which he has arrived:—Having observed that the solidity of castings did not depend solely on the observance of the known laws of the strength of materials, but also on phenomena connected with casting and cooling, and having called to mind the fact that it was frequently noticed in the foundries that castings intended to support great weights showed, on being taken out of moulds, cracks or faults, or at least exhibited them after having been submitted to slight shocks. Mr. Hagen generally attributes these accidents to interior tension within the casting, or to another phenomenon, supposed to consist of a kind of suction, which, like the tension, results from differences in withdrawal from the mould and cooling. Thus in the thin parts of small section, and in those which are salient or flat, the diminution of temperature is more rapid than in the solid portions of a casting, or in those which are nearer to a great mass of the metal, or, lastly, which form retiring angles The metal, which is in contact with the cold, damp mould, a conductor of caloric, also parts with this fluid much sooner that that which is only in contact with warm materials and bad conductors. Further, the molten iron, in passing through the get and the mould to reach the parts most distant from the tap-hole, transmits a portion of its heat to the surfaces with which it comes in contact, and cools sooner than that which remains near the get or in the neighborhood of surfaces heated previously by the passage of other metal. The effects of these causes and irregularities, says Mr. Hagen,

soon show themselves; those parts most rapidly cooled contract and causing a vacuum by the diminution of their volume, exercise a kind of suction on the neighboring metallic molecules. If the latter are still fluid, or, at any rate, have preserved sufficient heat to allow them to yield, there is no fear of tension, but, if the casting in those parts is solidified and incapable of yielding, the opposing forces acting within the casting must destroy or, at least, diminish its tenacity. These views are not very different from those held by most engineers in this country.

THE COMPOUND MARINE ENGINE.—A correspondence is published in the "Mail" between Mr. Charles Randolph, late senior partner of Randolph, Elder, & Co., and Mr. John L. K. Jamieson, at present representing that firm, relative to the invention or introduction of the compound marine engine. It appears that our contemporary had ascribed all the merit to Mr. Randolph's partner, the late Mr. John Elder, and Mr. Randolph calls upon Mr. Jamieson, to whom the article had been submitted prior to its publication, to put the matter right as regards his own claims in connection with the improvement in question. Mr. Jamieson declines to say "what proportion of merit should be divided between the partners," on the ground that he cannot do so "from his own knowledge." In justice to himself Mr. Randolph accordingly publishes the correspondence, which he closes with the following statement:—"I have no hesitation in affirming—First, that I alone originated the combined engine applied to marine purposes as made by Randolph, Elder & Co., arising out of my knowledge and experience of the superior economy of our double-cylinder factory engines as compared with marine engines in consumption of coal. I affirm secondly, that the designing of those engines was in great measure done by me; and, thirdly, that Mr. Elder on several occasions proposed to give up the making of the combined engine, and go back to the older but more wasteful forms of engine, rather than continue to combat the difficulties and uphill work of bringing it into general practice—which I am pleased to say is now the only engine generally adopted for marine purposes." Disputes of this kind are always more or less unpleasant; but "honor to whom honor is due." Mr. John Elder would have been the last man to claim any distinction which did not properly belong to him, nor would Mr. Randolph detract unfairly from the unquestionable merits of his deceased partner and friend. Suffice it that both gentlemen wrought well together during their prosperous business connection, and that the firm attained, through their united labors, with the zealous co-operation of the third partner of the firm, Mr. R. S. Cunliff, a great reputation among the ship-building and engineering firms of the world.—*Glasgow Citizen.*

SEWAGE OF ALDERSHOT—Mr. Rawlinson's report on this subject lately issued contains some points of much general interest. He states that "as an agricultural experiment, the Camp Sewage Farm is a success, land having no agricultural value in its natural state having been made (with the sewage) worth a rental of £25 per acre per annum; the cost to bring the land to this state, breaking up the subsoil crust, washing out the protoxide of iron, levelling the surface, and forming the sewage carriers, having been about £30 per acre, and occupying some three years of time." This farm consists of 89 acres, and has been in course of formation and cultivation during five years. The sewage of a population of 8,000 persons, "with about 200,000 gallons of water, passes through the land by means of irrigation, and though the statement is sufficiently shocking from a sanitary point of view, there is yet strong testimony to the efficacy of this method of deodorization in the recorded fact that the people break down the fences in order to get to the drain-ends—that is to the extent of the subsoil drains—to obtain this water for household use. Mr. Rawlinson does not, of course, mean to imply that the water is fit for drinking when he says "the whole sewage passes through the land under cultivation, so as to be clarified and disinfected, no portion of it flowing over the land, or leaving the land otherwise than by the subsoil drains, where it issues bright and sparkling."

FRENCH EXPERIMENTS WITH LIQUID FUEL.—For more than 10 years M. H. St. Clair Deville has been experimenting with mineral oils as fuel. "Comptes Rendus" and "Le Journal de l'Eclairage au Gaz" have lately published some interesting facts in regard to these experiments, a *resumé* of which is our present purpose.

The oils employed have been obtained from various natural sources, and the experiments have also included the heavy oil from the Parisian Gas Company's works.

The experiments have determined the following points: In 12 kinds of crude oils analyzed, there was found to be from 82 to 87.1 per cent. of carbon, 7.6 to 14.8 per cent. of hydrogen, and 0.9 to 10.4 per cent. of oxygen.

The heavy oil of the Parisian Gas Company has a specific gravity at 32 deg. Fahr. of 1.044, and at 88 deg. Fahr. 1.007. It is of a dark brown color, and contains 82 per cent. of carbon, 7.6 per cent. of hydrogen, and 10.4 per cent. of oxygen, nitrogen, and sulphur. Heated to 424 deg. Fahr., only 12.5 per cent volatilizes. It remains fluid at 12 deg. Fahr. A tun of it contains about 220 gallons, and its cost is about 50 francs per tun, or in round numbers 10 dollars in gold, our currency.

The amount of carbon added to the hydrogen contained in this fuel, must make it a very powerful heat-generating combustible. It has nearly the lowest expansibility of all the oils, its coefficient of expansion being 0.000743, and the lowest coefficient being 0.000652.

The most important experiments with the heavy oil were made with a locomotive of the Strasbourg Railway Company. This locomotive has uncoupled wheels and outside cylinders. Its weight is 20 tons, and that of the tender is 15 tons. It has a heating surface of 72 sq. yds.

The oil was supplied to the furnace from a tank, being fed by its own gravity. An additional supply was carried on the tender, wherewith to renew the supply in the tank as required.

The fire was kindled by lighting some shavings and sticks on the floor of the fireplace and at the same time admitting a small quantity of oil. A jet of steam was sent into the smoke pipe from the blow-off pipe of another engine, to increase the draft. It took an hour and a quarter to get up steam, during which time 11 gallons of oil were consumed. It was shown, however, that by consuming 12½ gallons of oil, steam could be got up in two and one half hours, without assistance from

another engine, but with the inconvenience of a large amount of dense black smoke.

On the first experimental trip it was found that a speed of 40 miles per hour was obtained with a consumption of about 14 lbs. of oil per mile.

In a second experiment a train of 70 tons was drawn at a speed of 40 miles per hour, with a consumption of about 17 lbs. of oil per mile.

Subsequent experiments gave results not differing essentially from those mentioned.

The grate consists of 20 bars of iron cast in one piece, with channels for the oil to run down, and it is set perpendicularly before the furnace, which is lined with fire brick. A separate cock supplies oil to each grate bar.—*Scientific American.*

Feathers in Mahogany and other Woods.—We have been asked by a correspondent for an explanation of the so-called "feathers" in the grain of mahogany, satin-wood, etc.; thinking other of our readers who have to do with woods may be interested in the subject, we offer the following explanation:

In the structure of all woods used in building, there is, firstly, a series of vessels of woody tissue surrounding the heart of the tree, having a *vertical* growth, and arranged in *annual concentric circles;* secondly, there are certain hard woody growths, called the "medullary rays," *radiating* from the heart, and consequently more or less *horizontal:* these vertical and horizontal growths are intimately but *regularly platted and intertwined together*, to give strength to the trunk, and thus far all is regularity. Now, where the branches burst through the stem, this regular arrangement is upset, and the above-mentioned woody vessels are disarranged, and pushed at different angles. When the tree is cut down and sawn horizontally across amongst these branches, these disrupted horizontal and vertical vessels (of different colors, be it remembered), are seen cut at every conceivable angle, and an ornamental "feather," more or less extensive, is the consequence. These feathers do not exist at the *base* of the tree, because there are no branches there to disturb the annual growths of the wood (minute feathers do indeed exist at the *very heart*, and these were caused by the growth of leaves and twigs when the tree was a seedling or little cutting). "Feathers" are not seen in *deal* because the fir is a straight-growing tree, without branches, in the portion of the trunk used in commerce. "Feathers" are seen most abundantly in "pollards," for the simple reason that after the top of the tree has been sawn off, an immense growth of branches is always induced, disturbing the tissues in every imaginable way, the action of the *light* on the "feathers," adds greatly to their beauty after the wood is polished.—*The Builder.*

Temple of Minerva Polias Priene, Asia Minor.—The newspapers have mentioned that a valuable collection of ancient marbles, the result of excavations by Mr. R. Popplewell Pullan, to whom the readers of the "Builder" have often been indebted for accounts of foreign cities, was on its way to England, and would be placed in the British Museum. The cases have now arrived and are being unpacked. They contain fragments of the sculptural and architectural adornments of the temple, including portions of the celebrated statue of Minerva, mentioned by Pausanias, a colossal female head of a fine period, parts of several draped statues, heads of the Macedonian time, and fragments of the frieze, which in style closely resembles the reliefs on the Mausoleum, and is believed, in fact, to be by the same hand. Besides the marbles discovered by Mr. Pullan, there are 33 cases, the fruits of the labors of Mr. Wood at Ephesus, and 2 cases sent from Asia Minor by Mr. Dennis, whose researches among the tombs of the Lydian kings at Sardis were abruptly brought to a close by the want of funds.

Mr. Pullan has been engaged in excavating ancient sites with varying results, at different times, during the last 8 years, at considerable risk, and may be congratulated on the result of his last undertaking. The temple as uncovered presents an octostyle plan; the steps and pavements being everywhere perfect. The walls of the naos and pronaos are standing in some places to a height of 6 ft., and the columns of the porticos to a height of 13 ft. or 14 ft. The whole is built of white marble, put together with iron cramps and copper dowels, and without mortar, and all the carved ornaments are of the most elegant workmanship. There is no other ruin in Asia Minor of a good date in so perfect a condition. The temples of Arzani and Euromus, which alone are more complete, are of a much later period. The site is a magnificent one, being on the side of a mountain, above the plain of the Mœander, and opposite the marshes which surround the site of Miletus. At the time when Mr. Pullan encamped on the spot, three-fourths of the population were suffering from intermittent fever, and before he had been at work long he and his principal workmen were attacked by it. He was compelled to suspend operations. The wintry storms were so violent, that their encampment was blown down, and he was compelled to build a house in the ruins. Add to these *contretemps*, that he had frequent notice from the Berlin consul, and from the Pacha, at Smyrna, as well as from the local authorities, that there were brigands in the vicinity, and that if he remained it would be entirely at his own risk, and it will be seen that such investigations require no small amount of courage and resolution.—*The Builder.*

Cornish Pumping Engines.—The number of pumping engines reported for November, is 20. They have consumed 1,225 tons of coal, and lifted 8.5 million tuns of water 10 fms. high. The average duty of the whole is, therefore, 46,700,000 lbs., lifted 1 ft. high, by the consumption of 112 lbs. of coal. The following engines have exceeded the average duty:

Chivertoon Moor, 70 in. ....Millions	54.0
Great Work, Leed's 60 in.	54.9
North Wheal Crofty, Trevenson's 80 in......	56.2
Providence Mines, 40 in.	48.5
South Wheal Frances, Marriott's 75 in......	54.4
West Wheal Seton, Harvey's 85 in..........	59.2
Wheal Seton, Tilly's 70 in	51.3
Wheal Seton, Tregonning's 70 in...........	68.9

Hardness of Metals.—An instrument for determining the hardness of metals has been invented by a French engineer. It consists of a drill, turned by a machine of a certain and uniform strength. The instrument indicates the number of revolutions made by the drill. From this, compared with the length of the bore-hole produced, the hardness of the metal is estimated. It is said that most rails are tested in France by this instrument.

VAN NOSTRAND'S ECLECTIC ENGINEERING MAGAZINE.

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THE KANSAS CITY BRIDGE.*

To this pioneer bridge across the Missouri there attaches an unusual degree of interest, quite enough to warrant the record contained in the handsome quarto volume devoted to the history of its construction.

Across the most fitful as well as the mightiest of our great rivers, the work was by turns imperilled by ice drift or rafts, as well as the heavy push and treacherous scour of its swift current.

How the numberless difficulties were surmounted by engineering expedients, some old and some new, the author describes as fully as can be desired.

We cull from the work so much for the present as relates to the superstructure, reserving for a future article the history of foundations, more especially Pier No. 4.

SUPERSTRUCTURE.

In the early part of August, 1867, letters were sent to a number of prominent American bridge-builders, inviting proposals for the superstructure of the Kansas City Bridge. These letters were accompanied by a set of specifications of general character, which were intended to serve rather as an indication of the quality of bridge wanted, than to contain the precise requirements of a contract. The lengths of the several spans, and the uses for which the bridge was building, were given in these specifications; they also stated that it was designed to build the draw entirely of iron, and the fixed spans of a combination of iron and wood, the latter material being used only to resist compressive strains; the moving loads to be assumed in the calculations were specified, as well as the strains to which the iron might be subjected, and the factor of safety to be used in the wooden parts. The builders, however, were invited to propose any form of truss which they might select, submitting plans of the same if novel, and to suggest such departure from these specifications as might in their judgment seem wise, with the reasons for the change, and a statement of the benefit resulting therefrom. At the same time a set of plans for the fixed spans was prepared by Mr. Tomlinson, under the direction of the chief engineer, which were to be adopted only if, on a fair examination, they were found to be preferable to those submitted by outside parties. It had been intended to prepare plans for the draw as well, but in consequence of the mass of detail which this would involve, and the shortness of the time, it was found impossible to do so.

Nine sets of proposals were received from five different parties, two being on the common Howe truss plan, with both chords of wood; of the other plans, three were adaptations of the Pratt truss, one being entirely of iron, and the remaining

* The Kansas City Bridge. By O. CHANUTE, C.E., and GEORGE MORISON, Assistant Engineer. New York: D. Van Nostrand. 1870.

four were respectively examples of the Post, the double and the single triangular, and the Fisk suspension trusses. On the 30th of October the contract was let to the Keystone Bridge Company, of Pittsburgh, Pa. ; the fixed spans were to be built according to the plans supplied by the chief engineer, the iron in them being paid for by the pound, and the timber by the foot ; the draw was to be built according to the contractors' design, for a fixed sum ; subject, however, to such alterations as might be suggested by the chief engineer, the Company to have the benefit of any saving which might result from such changes, and to pay any extra cost which they might involve. Under this provision certain changes were suggested in the depth of the truss and arrangement of panels, which resulted in a material reduction of the cost. By a subsequent arrangement a pony truss of wrought-iron, made by the contractors from their own designs, was built, in place of the composite structure proposed by the engineer for the shore span of 66 ft.

The general design of the fixed spans is that of a double triangular truss or trellis girder, in which the top chord, posts, and braces are of wood, and the other members of wrought-iron, cast-iron being used in the details and connections. This combination, which has been used as yet only to a limited extent, is believed to overcome the most objectionable features of a wooden bridge, avoiding the wasteful connections which accompany the use of wood in tension, and disposing of the bulk of the perishable material in places where it can easily be protected ; besides this, the character of the butt-joint connections, used to take compression, is such, that worn out parts can be removed and replaced by others without disturbing the remaining parts of the structure ; it is also possible to replace the wooden parts by iron, and thus gradually convert the bridge into an iron structure without the expense of false-works or the intermission of traffic. The braces, which are always open to the air on all sides, are exposed to moisture only during the actual prevalence of a storm, and would therefore be well protected by a thorough coating of paint. The top chord can be covered in, and thereby thoroughly protected from the weather, without perceptibly increasing the wind surface of the bridge. The only danger to which such a bridge can be exposed is that of fire, and if the wood-work be painted throughout with mineral paint, and a watch kept, which is always necessary at Kansas City, men being constantly needed to tend the draw, and collect tolls, this danger is reduced to almost nothing.

The trusses of the 5 fixed spans measure respectively 130, 198, 248, 198, and 176 ft., the difference between these distances and the lengths of spans, given in the preceding chapters, being the allowance made for pedestals, wall-plates, and clearance room. The two shortest of these have straight parallel chords, the depth of truss being 22 ft.; the same depth is retained at the ends of the larger spans, but in them the upper chord is arched so as to increase the central depth to $\frac{1}{8}$ of the length, the inclination of the braces being kept nearly constant by varying the lengths of the panels. The upper chord of the 130 ft. span is formed of 3 pieces, packed in the usual manner ; in the other spans the chord is of 5 parts, and supplemented at the centre by a sub-chord of 2 parts. The lower chords are of wrought-iron upset links with pin connections, made under the Linville and Piper patent. The end posts and braces bear upon a cast-iron pedestal, which rests on a wall-plate likewise of cast-iron, carefully fitted to the masonry, and well bedded with mortar ; at one end of each span a set of rollers is placed between the pedestal and the wall-plate. In place of the ordinary square ends the braces are cut with 2 end faces, which make an obtuse angle with one another, and the angle blocks are cast to correspond ; this device makes it impossible for a brace to slip upon its bearing, The ties are of square iron, with a welded loop at the lower end, passing around the chord pin, and a screw cut on the upper end, which is previously upset, so as to leave an equivalent area after the cutting of the screw. In the 130 ft. span both the main and counter braces are single, the counters bearing upon cast-iron brackets placed on the sides of the main braces ; the main and counter ties are in pairs running along the sides of the braces. In the other spans the main braces are in pairs, and the counters, which are single, pass between them. In the 176 ft. span both sets of ties are in pairs, the main ties

passing outside the main braces, and the counter ties between the main and counter braces. The arrangement of ties is the same in the central panels of the 198 and 248 ft. spans, but in the panels near the ends there are 4 main ties, 2 passing outside the main braces, and 2 between them and the counter. In all the spans the counter ties are carried only so far as the stiffness requires, but a counter brace is placed in every panel to take a bearing in screwing up the main ties.

The most novel detail of this truss is the top angle block; this is of cast-iron and formed of 3 forms of castings. The respective parts are: *First.* The angle-block proper or brace bearing, which is placed below the chord, and receives the ends of the braces in the central panels of the 4 largest spans; this is cast with extended ends, to form a connection with the sub-chord. *Second.* The keys which pass through the chord in much the same manner as ordinary packing blocks; they are cast hollow, in as many parts as there are spaces between the chord timbers, and with side plates to receive the ends of the timbers whenever a joint is broken. *Third.* The washer plates, which rest on the top of the chord and carry the nuts of the ties; the plates for the main and counter ties are cast separate. The brace-bearings are cast with flanges extending their whole length, which fit into grooves cut in the chords, and bear against the cast-iron keys; the ties pass through the hollow keys, nowhere coming in contact with the wood of the chords. As the ties take hold of the washer-plates above, and the braces rest against the bearing below, both of which bear upon the keys, the strain is distributed, from the first, through the whole section of chord, instead of being thrown entirely upon one edge, as is usual in wooden bridges. The keys also serve to throw the vertical component of the strain in the ties, directly upon the braces, without the intervention of the soft wooden chord.

The lower angle-block, or brace-bearing, is cast in a single piece, having a series of webs on the under side through which the pin passes.

The top laterals are of the pattern commonly used with the Howe truss, except that the bearing of the half struts is taken by small castings placed around the centre of the long strut, instead of being thrown directly upon the wood. The bottom laterals have cross struts and diagonal ties, each strut extending from the foot of a post to the opposite point on the chord-link of the other truss; the ties connect at one side with an eye-plate which fits over the chord-pin, and at the other with bent rods attached by nuts and a casting to the chord-link; each tie is in 2 parts, the adjustment being made with a sleeve nut.

The floor beams, of which there are 2 in each panel, are formed of 2 pieces of pine, each 6 by 15 in., placed side by side and trussed; they are placed above the lower chord and rest upon cast-iron plates with raised centres, by which the weight is distributed equally upon the several links. Owing to the skew of the bridge, which is reduced to 6 ft. 3 in. in the superstructure, the 2 floor beams which come in the same panel on one truss are divided on the other. The floor stringers, running lengthwise with the bridge, are 7 in number, those under the rails being each formed of 2 pieces of 7 by 14 in. pine; on these are laid 2 courses of $1\frac{1}{4}$ in. matched flooring placed diagonally, the planks of the second course crossing those of the first, 3 layers of tarred paper, heavily coated with fresh roofing pitch, being placed between the two; on these is laid a Nicholson pavement 4 in. thick, the whole being covered with sand and pitch in much the usual manner. The rail is of the street rail pattern, weighing 68 lbs. to the yard, and made at the Palo Alto Rolling Mill, at Pottsville, Pa.; it is laid on a longitudinal strip of oak resting on the pine flooring. The floor is given a slight arch, and is drained into gutters on each side, which discharge through cast-iron scuppers, placed at such intervals as to avoid wetting the floor beams.

A foot-walk is placed upon the west side of the bridge, supported by brackets which are bolted to the floor beams; the floor is made of 2 in. plank and a substantial wooden hand-rail is placed on the outside. The top chord is protected from the weather by a covering of pine boards, finished with a narrow overhanging cornice ornamented with brackets. The whole superstructure, including the iron parts, is painted with 3 heavy coats of a mixture of oil and crushed iron ore, manufactured by the Iron-Clad Paint

Company, Cleveland, Ohio; all cracks and weather checks in the timber having been stopped with putty, after putting on the first coat. The wooden keys and all joint-bearings were painted with the same composition before putting the truss together, and the closed covering is covered with a roofing paper made by coating thick brown paper with a coarse variety of this paint.

As the trusses are subject to a double deflection, the expansion of the lower chord under an increase of temperature operating in this way, as well as the strains produced by a load, they are built with a somewhat greater camber than is usually put in railroad bridges; the camber of the 248 ft. span is $8\frac{1}{2}$ in., that of the 198 ft. span 7 in., and those of the 176 and 130 ft. spans, respectively, $5\frac{1}{2}$ and $4\frac{1}{2}$ in. These cambers, however, are materially in excess of any actual deflection.

In proportioning the trusses the central tie rods and the truss rods of the floor beams were allowed to bear a strain of 10,000 pounds to the sq. in. each floor beam being supposed to take the greatest load which the drivers of a locomotive could possibly throw upon it, and no allowance being made for the stiffness of the timber under a transverse strain; the strain in the end ties and chord-links was limited to 12,000 lbs. per sq. in., but no allowance was made for the reduction of strain which the curvature of the upper chord would make in the end panels of the web. This practice of allowing a greater strain per sq. in. on those parts which are fully strained only under a maximum load, than on those which are liable to be strained to the full calculated amount by any heavy locomotive, is believed to have originated with Mr. Albert Fink, and is thought to be a more accurate method of proportioning than the common one, which makes no difference in strain per sq. in. on the different parts under a maximum load. The strain upon the timber of the top chord was limited to 800 lbs. on the sq. in., the braces were proportioned by the well-known formula of Hodgkinson, 7 being the factor of safety adopted. The assumed moving load was 2,240 lbs. per running ft. for the 4 longest spans, and 2,800 lbs. for the 130 ft. span.

The trusses are anchored to the piers by long rods of $1\frac{1}{2}$ in. round iron, which, extending from the top chord, pass over cast-iron struts projecting outwards from the coping, and are fastened by nut and screw through the eye of a 3 in. pin set 15 in. into the masonry. The trusses are further stiffened by corner braces extending from the end posts to a cross stretcher overhead, and the 3 longest spans have sets of similar braces placed at intervals through their length.

The amount of material in the several trusses, including floor beams and stringers, is as follows:

Length of Span.	Timber.	Wrought-Iron.	Cast-Iron.
130	35,739ft. B.M.	44,053 lbs.	27,137 lbs.
176	57,854 "	72,969 "	49,491 "
198	78,277 "	89,449 "	54,119 "
248	101,688 "	147,432 "	70,646 "

To this must be added 194,911 ft. B. M. of pine lumber, 24,167 ft. of oak, 7,200 lbs. of wrought-iron, and 1,700 lbs. of cast-iron, used in the planking, pavement blocks, hand rail, vertical bracing, anchor rods and chord covering, on the fixed spans; this additional amount includes the floor and footway of the 66 ft. span.

The method of manufacture by which the wrought-iron parts were prepared rendered them free from the common danger of defective welds. The chord links were made by upsetting the ends of flat bars of rolled iron till an increase of section somewhat in excess of that required was obtained, and then working down under the hammer and drilling the hole for the pin, leaving them absolutely free from welds. The only weld in the panel ties was that formed in joining the return end of the loop to the long bar; this weld would at most be exposed to but half the strain upon the tie; and even if the weld were absolutely worthless, the tie would have the full strength of a hook around the chord-pin. For these reasons, it was not considered desirable to test every piece of iron with a moderate strain of 20,000 to 25,000 lbs. to the in., as is often done for similar works. Such a strain could at most be expected to reveal the defects of manufacture, which the methods here adopted precluded the possibility of; while the effect of such a

strain, by giving a set to the iron, and imparing its perfect elasticity, would be deleterious rather than otherwise. Samples of the iron were, however, taken and tested to breaking in an hydraulic tester under a slow and long-continued strain, with the following results :

First Test.—Bar, $1\frac{1}{2}$ in. sq., with welded loop at each end, length 5 ft. between centres of loops. Four equal spaces of one foot each were laid out on the central part of the bar. No perceptible extension was noted with a strain of 10,000 lbs. per sq. in., and but little with 20,000 lbs. With a total strain of 130,000 lbs., equal to 57,777 lbs. per sq. in., the length had increased six inches, and the bar yielded by the opening of one of the welds. The four spaces, after the removal of the bar, measured respectively $12\frac{15}{16}$, $12\frac{11}{16}$, $12\frac{3}{4}$ and $13\frac{1}{8}$ in ; the last including a part of the broken weld.

Second Test.—Bar 2 in. sq., 9 ft. long, with loop on one end and nut on the other, extended by strain of 130,000 lbs. 1 in. by 160,000 lbs. 3 in., by 176,000 lbs. $4\frac{1}{2}$ in., by 200,0001 bs. 8 in., and by 221,000 lbs. 12 in., when it broke about 18 in. from the nut, showing a fine fibre-like fracture, the strain being 55,250 lbs. to each original inch of section; but the reduced section at the break was only 2.85 sq. in., making the strain somewhat over 77,000 lbs. to the square inch. Five equal spaces of one foot each, laid off on the bar before straining, measured after the break $13\frac{1}{8}$, $13\frac{7}{8}$, $13\frac{9}{16}$, $13\frac{7}{16}$ and $13\frac{1}{2}$ in.

Third Test.—Bar $1\frac{3}{4}$ in. sq., 38 ft. long, and 3.0625 sq. in., under the following strain extended as given below:

	Lbs.	Lbs. to sq. inch.		In.
Total strain	26,000	8,500	Extension	$\frac{1}{8}$
" "	52,000	17,000	"	$\frac{17}{64}$
" "	78,000	25,500	"	$\frac{25}{64}$

No perceptible set after strain of 28,000 lbs. on the square inch.

A number of tests were made at the same time of iron of the same quality manufacturing for the Dubuque bridge, with similar results. This iron is of the kind known as Kloman's mixture, manufactured at the Union Iron Mills, Pittsburg, the ties and truss-rods being made of double-rolled, refined iron. The bar broken in the second test was afterwards cut up, and three small pieces were turned out of it, each having a reduced central diameter. These were taken to the Fort Pitt Foundry, and tested in the lever machine belonging to the U. S. Government; two of these tore out of the clutches before breaking, when the strains per square inch were respectively 62,760 lbs. and 63,134 lbs. The last specimen broke under a strain of 84,032 lbs. per sq. in., and showed a beautiful fracture entirely fibrous.

The cast-iron used in the details was a gray iron formed of a mixture of pig, generally adopted by the Keystone Bridge Company.

Specimens were tested by suspending a weight upon a bar two inches by one, and placed upon support four feet apart. The specifications required that this breaking weight should not be less than 2,100 lbs., and in all of the tests it was found to be much in excess of this amount.

The shore span is a riveted trellis girder of wrought-iron 71 ft. long and 8 ft. deep. The chords are of T section, composed of two vertical plates, one horizontal plate and two angle pieces ; in the bottom chord the horizontal plate does not reach to the ends of the span, and the other parts are continuous for the whole length. The braces are each formed of two pieces of T iron placed back to back, and enclosing the ties, which are single bars of flat iron ; both ties and braces are riveted between the vertical chord plates. The laterals are of wrought-iron, and the trusses are stiffened by short braces of T iron connecting the floor with the web. The end posts are enclosed in light ornamental castings. The floor beams are of pine, 6 in. by 18, without trussing, placed 2 ft, between centres; on this is laid a floor similar to that on the other fixed spans. The amount of material in this span, exclusive of pavement and hand rail, is as follows : Lumber, 7,684 ft. B. M.; wrought-iron, 32,165 lbs.; cast-iron, 4,328 lbs.

The draw measures 361 ft. and 3 in. over all; it is a Pratt truss of similar plan to the large draws erected by the Keystone Bridge Company at Cleveland, Dubuque, and other points. The skew is taken out of the truss by making the end panels of unequal lengths, the difference being 5 ft. 6 in. The upper and lower chords are of like pattern, formed of two I beams and two channel bars 8 in. deep,

placed side by side and united by a plate riveted to their upper flanges. The posts are of wrought-iron, of the Linville pattern. The ties are round, with both ends upset for screws ; the main ties are in pairs, and the counters single, passing through the posts. The washer plates upon which bear the nuts of the ties are of cast-iron, except the top centre, which is forged. The floor beams are 10-in. rolled I beams, and rest on the top of the lower chord. The floor is of 2-in. oak plank laid on the oak track stringers, and pine floor joists. There is no separate footway on the draw. The turn-table is formed of an external drum 30 ft. in diameter, and a central shell of cast-iron, hung by ten bolts on one of Sellers' patent pivots ; the drum and shell are connected by a pair of plate girders under the centre posts, and a set of radial rods. The bolts are adjusted so as to throw almost the entire weight on the centre, the drum serving only as a guide and balancer. The draw is easily opened by four men, with levers attached to two pinions on the drum, in two minutes, but as a precaution against wind and other dangers, it is to be fitted with a steam-engine. The latch is worked from the centre by a hand-lever; a bearing is secured by wedges which are driven under the four end-posts, the four being worked by a single central lever. The amount of material in the draw, including both trusses and turn-table, is as follows: Timber (in floor), 26,025 ft. B. M.; wrought-iron, 495,575 lbs.; cast-iron, 122,041 lbs.

In proportioning the draw, it was supposed to carry the whole dead load on the central bearing when swung, and each arm was supposed to carry its share of the dead load, and a moving load of one ton to the foot when closed, no allowance being made for the continuity of the chords. Though this has been the method by which most of the large iron draws lately built have been proportioned, the engineers were convinced that it is a method of computation which gives very erroneous results, showing the central strains, especially in the web, to be much less than they really are, with corresponding excesses in other parts ; a set of calculations believed to be based on a more correct hypothesis will be found in a subsequent chapter. The distribution of strain is regulated by the proportion of the total weight thrown upon the end piers, and is therefore largely dependent on the form of latch used. The wedges under the end posts have but a small lifting power, as is fully proved by the action of the draw under a passing load, a heavy freight train, covering one arm only, causing the further end to rise from its bearings $\frac{7}{8}$ of an inch. A set of hydraulic jacks are to be substituted for the wedge plates, the jacks being placed within the hollow end-posts and worked from the turn-table by pumps driven by the steam-engine ; it is thought that under this arrangement a sufficient lifting power can be obtained to make the proportioning of the draw sufficiently correct to prevent distortion. * * *

The greatest difficulties occurred in the case of the span between Piers 3 and 4, where the strength of the current and the depth of the water, especially near Pier No. 3, would have carried away any common false-works in a very few hours. The distance between the caisson around Pier No. 3 and the false-works at No. 4 was divided into four nearly equal spaces. Between the first and second of these spaces, a cluster of eight piles in two rows 8 ft. apart was driven in 35 ft. of water, the piles being kept from washing out by guying them with lines as fast as driven ; a crib of round timber was then built, enclosing the piles, which on being sunk by filling it with stones, should at once retard the wash and bind the piles together. A precisely similar arrangement was adopted between the second and third spaces. This work was begun on the 10th of March ; on the 14th the weather became very cold, and the ice began to run in large quantities ; the numerous obstructions of the false-works impeded the flow of ice, and in the forenoon of the 16th it jammed at the bridge site and the river became closed. The weather had already begun to moderate, and in the afternoon of the same day the ice moved out ; it was very weak, but the cakes had packed together, forming large thick fields, which, however, were too soft to bear the weight of a man. The sixteen piles of the two clusters had been driven, a crib had been built about the first cluster, though not sunk, and carpenters were at work upon the second crib, when the ice began to move across the whole width of the river at once ; it tore out all

of the sixteen piles, taking the cribs with them, and carried along with it the pile-driver, barges and men. The boats moved but slowly, being frequently retarded by ice jams, and while still opposite the town they were overtaken by the steamboat and secured, having suffered no material damage ; but no trace of piles or crib-work remained, and two months later one of the cribs was observed 40 miles down the river, with a pile still remaining in it. This gorge was accompanied by a considerable scour, the water at the site of the second set of piles having been deepened about 12 ft.

The piles were at once replaced, and the cribs built, sunk, and protected by additional riprap ; the piles were then capped and surmounted by trestle piers, which were planked on the sides and provided with timber starlings, 8 or 10 ft. high, as a protection against drift. * *

The draw span was raised on false-works extending from the pivot pier to the upper and lower rests. As the small amount of sand above the rock precluded the driving of piles, these works were built on cribs, two of which, loaded with stone, were placed between the pier and each rest. These cribs were originally intended to serve as the foundation of a permanent draw protection ; they were built in the winter of 1868–9 ; were made 30 ft. square, and divided by four cross-walls into nine compartments. The deadening effect of the upper rest and pier on the current, had so checked the scour that the cribs did not settle to the rock, and as their bearing was not thought to be firm enough to carry a permanent structure, they were built up above ordinary high-water, and a wooden truss, strong enough to sustain itself if the cribs settled, and which should serve as false-works for raising the draw, was built upon them.

As soon as Pier No. 2 had been completed, the pivot was placed upon it, and the turn-table put together ; the chords were then spread out and riveted, and the bridge trusses made self-sustaining at the earliest possible moment, the whole structure being raised in about six weeks. The cribs settled slightly under the weight of iron, but not enough to give trouble, the subsidence being remedied by additional blocking. Since then the upper cribs have not settled materially, and are probably on their permanent bearing ; but the night after the weight of the truss had been taken off the false-works, a rise in the river scoured around the two lower cribs, causing them to settle away from the truss ; under the continued scour of the summer flood they continued to settle, tilting from side to side, and finally, when the flood was at its height, they tipped over and rolled away ; the false-work truss remains standing, and no harm was done to the works.

On the occasion of the public opening on the 3d of July, the bridge was tested in the presence of a number of engineers invited to examine it, with the following results. We give the results of the long span and draw only :

248 FOOT SPAN.

Fully loaded	233 Tons.
North quarter Deflection	$\frac{51}{32}$ Inch.
Centre "	$\frac{69}{32}$ "
South quarter "	$\frac{48}{32}$ "
Permanent Set	$\frac{5}{32}$ "
Elongation of Bottom Chord	$\frac{3}{8}$ "

DRAW SPAN.

North Arm Loaded	170 Tons.
North quarter Deflection	$\frac{23}{32}$ Inch.
Centre "	$\frac{34}{32}$ "
South quarter "	$\frac{15}{32}$ "
Centre of South Arm rose	$\frac{19}{32}$ "
Both Arms loaded	313 Tons.
Centre Deflection, North Arm	$\frac{19}{32}$ Inch.
Permanent Set " "	$\frac{1}{8}$ "
North quarter Deflection, South Arm	$\frac{15}{32}$ "
Centre Deflection, South Arm	$\frac{18}{32}$ "
South quarter Deflection, South Arm	$\frac{9}{32}$ "
Permanent Set	$\frac{3}{8}$ "

It is to be noted that these tests were made before the bridge had been screwed up under a load, and while the bearings were not perfectly close ; they cons quently show greater deflection than a subsequent testing would indicate.

The Hoosac Tunnel, it is reported, is now progressing at the rate of 10 ft. a day—4 ft. from the west end, and 6 ft. from the east end. The central shaft is complete ; its depth to the floor of the tunnel is 1,030 ft. Work at the new headings is already begun. The tunnel has been excavated 11,765 ft. at both portals, that is, 6,946 ft. at east side, and 4,819 ft. on the west side.

ON THE MANUFACTURE OF IRON AND STEEL BY DIRECT METHODS.*

Although by far the greater part of the wrought iron and steel now used in the arts is made from cast iron produced in the blast-furnace, the history of iron-making shows us that in early times malleable iron, and even steel, were obtained directly from certain ores, without the previous production of cast iron, and without fusion. The manufacture and use of the latter, in fact, date only from a comparatively recent period. The natives of India, Burmah, Borneo, Madagascar, and some parts of Africa, practise the direct conversion of iron ores to the metallic state in small furnaces. In certain districts of India the amount of malleable iron thus produced is very considerable, and much of it is manufactured into steel; but the furnaces used are small in size, and produce not more than from 20 to 40 lbs. of iron in a day, with the labor of three or four men, and with a great waste of ore and of charcoal. The rich native ores, coarsely pulverized, or the grains of iron ore obtained by washing the sands of certain districts, are heated with charcoal in small furnaces, until they are reduced and yield masses of malleable metal. Somewhat similar methods of making malleable iron have long been known in various countries of Europe, where, under improved forms, they are still followed, and have thence been brought to America. Of these furnaces for the direct conversion of ores into malleable iron, the five known in Europe are the Corsican and Catalan forges, the German bloomary forge, the Osmund furnace, and the German Stuckofen or high-bloomary furnace, which latter had high walls, and approached in form to the modern blast-furnace, of which it seems to have been the immediate precursor. For a detailed description of these various furnaces, and the mode of working them, the reader is referred to Dr. Percy's learned work on the metallurgy of iron and steel. Inasmuch, however, as furnaces related to the German bloomary are still largely used on this continent, and promise to become of considerable importance to Canada, it will be well to describe briefly some points in the history of these various European furnaces.

Of these, the best known is the Catalan furnace or forge, so called from the province of Catalonia, in Spain, where it was formerly much used, as well as in the neighboring parts of France. The department of Ariège, in 1840, had in operation 49 of these furnaces, producing 5,800 tons of metal, of which 215 tons were a crude kind of steel, the remainder being malleable iron. The process has there, however, since probably fallen into disuse. Similar forges continue to be employed on the Italian coast, and, in 1850, there were 40 of them in operation in the province of Genoa, where they were used for the treatment of specular iron ore brought from the island of Elba. In the French Pyrenees, however (department of Ariège), the ore generally used in these furnaces is a hydrous brown oxide, holding from 40 to 50 per cent. of iron, and approaching in its character to the bog ores of the province of Quebec.

The Catalan forge consists of a rectangular hearth, constructed chiefly of heavy iron plates, which, in the largest size, is about 40 by 32 in., and from 24 to 27 in. deep, or from 14 to 15 in. below the twyer. In some districts, however, furnaces of not more than one-half these dimensions are built. The pressure of the blast employed does not exceed $1\frac{1}{2}$ or $1\frac{3}{4}$ in. of mercury, and the twyer is directed downwards, at an angle of 30 or 40 deg. The wall facing the twyer, slopes outward towards the top, and in working, the greater part of the charge of ore is heaped against it, and occupies from one-third to one-half of the cavity of the furnace, the remaining space being filled with ignited charcoal. The ore is previously broken so that the large lumps are not more than 2 in. in diameter, while from one-third to one-half of the material will pass through a screen, the bars of which are four-tenths of an in. apart. This finer ore is thrown on the surface of the fire, from time to time, during the operation, which is conducted with many precautions as to regulating the blast, stirring, supplying the fine ore and coal.

* Extract from the Report of Dr. T. Sterry Hunt, Chemist and Mineralogist of the Canadian Geological Survey.

At the end of 6 hours, in the ordinary routine, there is withdrawn from the bottom of the furnace an agglomerated mass of reduced but unmelted iron, which is then forged into blooms or bars. The operation, lasting 6 hours, consumes, in one of the larger sized forges, about $9\frac{1}{2}$ cwt. of ore and $10\frac{1}{2}$ cwt. of charcoal, and yields 3 cwt. of bar iron. According to another calculation, there are required for the production of 100 lbs. of iron, 340 lbs. of charcoal and 312 lbs. of an ore containing from 45 to 48 per cent. of iron. Of this about seven-tenths are obtained in the metallic state, the remaining three-tenths passing into the slag. 100 lbs. of ore yield 31 lbs. of bar iron, and 41 lbs. of slags, which are dark-colored basic silicates, very rich in oxide of iron.

The Corsican forge is a more primitive form of furnace than the Catalan, and without interest, except so far as it belongs to the history of iron-working. It is said to have consumed more than 800 lbs. of charcoal for the production of 100 lbs. of iron. Some few of these forges were still in operation in Corsica forty years since.

Another form of furnace, described by Dr. Percy under the name of the Osmund furnace, was used during the last century in Norway and Sweden. It was a rude hearth, with walls around it, and an opening in one of the sides near the tap-hole, which was built up with stones, and taken down when it was required to extract the loup or mass of reduced iron. This furnace was not capable of yielding more than $1\frac{1}{2}$ tons of iron in a week, but is still used in Finland ; and it is mentioned as a curious fact, that certain bog ores which contain so much phosphorus as to yield but a poor and hot-short iron by treatment in the blast-furnace, and subsequent decarburation, afford a good malleable iron when reduced by the direct method, in the Osmund furnace ; a result which appears to be due to the fact that the phosphorus, which is reduced and passes into the iron, in the blast-furnace, escapes reduction at the lower temperature of the Osmund furnace.

An improvement in the Catalan forge has been introduced in the province of Genoa, in northern Italy, and consists in the utilization of the waste heat, which is made to roast, and subsequently partially to reduce, the ore before treating it in the forge. For this purpose a flat-bedded reverberatory furnace, so constructed as to receive, at one end, the flame from the forge, was provided at the other end with a charging-door, within and above which was a vertical chamber, communicating with the chimney, and having a side-door, and a grating at the bottom. Upon this grating, the ore, a specular oxide containing 68 per cent. of iron, was laid, and exposed to the heat, which roasted it, expelling a small portion of sulphur. After being thus heated for some time, it was withdrawn and thrown into water, by which process it was rendered friable. Being then broken into small lumps and coarse powder, it was spread out evenly on a layer of broken charcoal, with which the bottom of the reverberatory hearth had previously been covered, and was here exposed to the heating effect of the waste flame from the forge, during the whole time of working a charge in the latter. In this operation the bed of charcoal was consumed, and the ore lost 10 or 12 per cent. of its weight, being partially deoxidized. Some scraps of cast iron or wrought iron were then added to the half-reduced ore, and the whole mass, by means of a rabble introduced through the charging-door, was pushed forward into the forge-hearth. In this way 5 heats, instead of 4, could be worked off in 24 hours, with great economy in charcoal, improvement in the quality of iron, and a somewhat greater yield. Separate furnaces were also constructed in connection with these works, for reheating the iron to be drawn out into blooms, and the waste heat from these was also employed in heating reverberatories, as above explained.

One of the Catalan forges, with these improvements, yields in a week of 6 days, 30 heats of iron, with an average consumption, for each heat, of 95.30 kilogrammes of ore in lumps, 63.50 of ore in powder, 31.75 of wrought-iron scrap, and 254.00 of charcoal, with a yield of 143.00 kilogrammes of bar iron. This is equal to 1,575 lbs. of iron in 24 hours, with a consumption of 2,794 lbs. of charcoal. It is, however, to be noticed that about 22 per cent. of this product, or 349 lbs., was added in the condition of wrought-iron scrap, whose re-working would consume comparatively little charcoal. Making a liberal allowance for this, we may fairly consider the work of the furnace as nearly

equal to the production, from the ore, of 1,400 lbs. of iron, which is at the rate of 50 lbs. of iron for 100 lbs. of charcoal consumed, and is about the result obtained with the American bloomaries, to be noticed farther on ; while the proportion obtained with the unimproved Catalan forge, described above, is only at the rate of 30 lbs. of iron to 100 lbs. of charcoal.

Mention has already been made of the German high-bloomary furnace, or Stuckofen, which is of no particular interest in this connection, and is not to be confounded with another furnace known simply as the German bloomary. This was formerly used in Silesia and the Palatinate, and is described at some length in the classic work of Karsten, written a little more than half a century since (1816), but is dismissed with a few words in Bruno Kerl's treatise on metallurgy, published in 1864 ("Huttenkunde," iii., 427), from which its use would seem to be nearly or quite abandoned in Germany. According to Karsten, the German bloomary consisted of an iron pot, or a box of iron plates, in either case lined with refractory bricks, and having an internal diameter of from 14 to 21 in., and the same depth, the dimensions varying with the fusibility of the ore, the force of the blast and the quality of the coal. The twyer was horizontal ; the furnace having been filled and heaped up with burning charcoal, the ore was thrown upon the fire by shovelfuls at a time ; this process was continued, the supply of fuel being renewed, until a loup of sufficient size had been formed at the bottom of the hearth, as already described in the Catalan method. When the blast is too intense, or the coal very dense, it may happen that the reduced iron becomes carburetted to such an extent as to produce steel-like iron, or even molten cast-iron, instead of a loup of soft malleable iron. A similar state of things sometimes occurs in the Catalan forge, and is occasionally taken advantage of to obtain an imperfect kind of steel.

From the above description it will be seen that the method by the German bloomary differs from that by the Catalan forge, in the fact that, in the latter, the greater part of the charge of ore is placed, at the commencement of the operation, in a coarsely broken state, on the sloping wall of the furnace, opposite to the twyer, while the remaining portion is subsequently projected, in a more finely divided condition, upon the surface of the fire. In the German method, on the contrary, the whole of the ore is reduced to this finer condition, and is added by small portions, a plan which dispenses with the charging of the furnace after each operation, as in the Catalan method, and permits of a continuous working, interrupted only by the withdrawing of the loups from time to time. The German bloomary, in an improved form, is extensively used for the reduction of iron ores in the United States, where it is known by the name of the bloomary fire, the Jersey forge, or the Champlain forge, and is also frequently called the Catalan forge, from which, as has already been shown, it is distinct in form, and still more distinct in the manner in which it is worked. Before proceeding to describe in detail the American bloomary fire, it will be well to notice some of the advantages of the direct methods of extracting iron from its ores, and to point out the conditions under which they may be used with advantage.

Karsten remarks that the iron ore obtained by a direct process is often of a superior quality, for the reason that the separation of the foreign matters of the ore is effected by a kind of liquation, rather than by complete fusion ; and, moreover, that certain impurities, which would be reduced and unite with the iron at higher temperatures, are carried off by the slags, in an unreduced state, at the lower heat of the open forge. A striking illustration of that has been given above, in speaking of the Osmund furnace, and its use in Finland. For these reasons Karsten was of the opinion that in some regions, and with certain ores, the direct process was, perhaps, more advantageous than the use of the blast-furnace combined with the finery-hearth. This, however, was half a century since, and, in the meantime, great improvements have been made in the manufacture of cast-iron, as well as in puddling or otherwise treating the pig-metal. In view of all these facts, and of the greater facilities for transportation at the present day, Dr. Percy observes (in 1864), "that there can only be comparatively few localities in Europe where these (Catalan) forges can be conducted with profit. In mountainous regions abounding in rich iron ores and

wood suitable for charcoal, and still inaccessible to railways, the Catalan process may hold its ground, but certainly not in localities where it is unprotected by high rates of carriage, or other circumstances, from competition with iron smelted and manufactured by modern processes. Its advantages are that the outlay and floating capital required for a forge are inconsiderable, and the consumption of charcoal is comparatively small."—(Percy, "Metallurgy of Iron and Steel," page 311.)

The German bloomary process was probably introduced into North America early in the last century. Among the forges in operation in New Jersey and Pennsylvania in 1856, Lesley, in his "Iron Manufacturers' Guide," mentions one as having been established in 1733, and another in 1725. These were, perhaps, bloomaries for the conversion of pig-iron by the Walloon method, which was used in this region at an early date ; but it is evident, from facts cited already, that the treatment of pulverized iron ores in the German bloomary fire was already practised in Connecticut as early as 1761. It was, probably, the coming of German immigrants which led to the use of the German rather than the Catalan forge, which, so far as I can learn, is unknown, at least, in the northern and eastern parts of the United States. Various improvements have been, from time to time, made in the construction of the furnaces, the most important of which has been the introduction of the hot blast. Favored by supplies of rich ores, and protected, to a certain extent, from foreign competition, by duties on imported iron, the manufacture of iron by this method has been widely extended over the United States, and has assumed considerable importance. In the districts where it was first introduced, including northern New Jersey and the adjacent portions of New York and Pennsylvania. the bloomary process is falling into disuse, since wood has become scarce, and extensive workings of coal in the vicinity, with the great facilities for transportation, have rendered it more profitable to treat the ores in the blast-furnace than in the bloomary fire. In northern New York, on the contrary, the use of the direct process appears to have considerably extended during the past few years.

The works for producing iron directly from the ores, by the present method, are known in the United States as forges or bloomaries, and sometimes consist of 20 forge-fires or furnaces, but in many cases of not more than 2 or 3. According to the report prepared by Mr. Charles E. Smith, for the "Iron Manufacturer's Guide" (page 760), and published by authority of the American Iron Association, there were, in the year 1856, produced directly from the ore, 28,633 tons of malleable iron, from 203 forge-fires. Of these, 42 were in New-York, 48 in New Jersey, 36 in North Carolina, 14 in Alabama, and 50 in Tennessee. There were besides, at that time 35 abandoned fires, of which not less than 29 were in New Jersey. The average production from each forge-fire was thus 141 tons. Since that time I have no means of knowing the condition of this manufacture in the south and west. In New Jersey, for reasons already given, the direct method is almost abandoned, while in northern New York, on the contrary, it has greatly increased. Instead of the 42 fires reported in 1856, there were, in 1867, according to the "Iron and Steel Association Bulletin," 136 fires in activity in Essex and Clinton counties, the principal seats of this industry. The aggregate product of these forges was supposed by a competent authority, in 1868, to be nearly 40,000 tons of malleable iron, a large portion of which is consumed at Pittsburgh for the manufacture of steel by cementation, a process for which this iron is eminently fitted, and for which that reduced from the ore of the Palmer ore-bed, near Keeseville, is especially prized. Two establishments in the neighborhood work the ore of this deposit ; one, that of Messrs. Rogers, of Ausable Forks, had 21 fires, and the other, that of the Peru Company, of Clintonville, 18 fires, in 1868.

The direct method of reduction cannot be applied to poor ores, which, to yield good results in the German or Catalan forge, should not contain much less than 50 per cent. of iron, while much richer ores are to be preferred. Some of the iron ores of North America consist of an aggregate of crystalline grains of magnetic oxide, mingled with so large a proportion of calcareous or silicious matter as render them unfit for the bloomary fire, without purification. This is generally effected by crushing and washing, after a previous partial calcination, and leaves the ore in

a coarsely granular state, which would not be adapted to the Catalan, although well suited to the German or American method. This condition of things is illustrated by the ore of the famous Palmer bed, just mentioned. I was informed at the works of Messrs. Rogers, that from 4 to 5 tons of the average crude ore were required to make a ton of blooms. The ore, as raised from the mine, is chiefly magnetite, with grains of white quartz, and, in some portions, of flesh-red feldspar. It is slightly roasted, to render it friable, then stamped and passed through screens with openings of about ⅛ of an in., and purified by washing. Two tons of the washed ore were required to make a ton of blooms. I took what seemed an average sample of the crushed ore from the stamps, and having further reduced it so that it would pass through the meshes of a sieve having 16 holes to the linear in., carefully separated the magnetic from the non-magnetic part, which contained a proportion of grains of specular iron ore, but was chiefly quartz. The magnetic portion equalled 45 per cent. of the whole. A sample of the dressed ore, such as supplied to the bloomaries, was treated in the same manner, by further crushing, and separation by the magnet, and contained 64 per cent. of magnetic ore; the non-magnetic portion, besides silicious matters, holding a considerable proportion of grains of specular iron, which would probably raise the amount of oxide of iron in this sample of the water-dressed ore to about 85 per cent., or a little over 60 per cent. of metallic iron. In other districts of northern New York, as in the vicinity of Port Henry, the crude ores are richer than those just mentioned, and often contain very little extraneous matter, so that the operation of washing may sometimes be dispensed with. At the new Russia forge, in Moriah, the ore, which is mingled with a little quartz, is roasted in piles, with wood, during two or three days, then crushed and treated as above described. Two tons of the crude ore yield 1½ of dressed ore, which is calculated to give 1 ton of blooms. The washing process removes not only the foreign matters, but a portion of fine ore, which is lost, and may be seen accumulated in the vicinity of the washing-tables. The bloomers, as the iron-makers are called, object to this fine ore, as being unfit for use; but it will be seen further on that this prejudice is without foundation, and that the finer grains can be used with advantage, though they are now rejected, and considerable loss is thereby incurred.

The magnetic ores of Lake Champlain are exported to Vermont, where, for several years, a few bloomaries have been supplied with iron ore from the west side of the lake. Three forge-fires were, in 1868, in operation at Salisbury, and 3 at East Middlebury, Vermont, 5 miles from the Middlebury station on the Rutland and Burlington Railway. The ore for this purpose is brought by water from Port Henry or Port Kent to Burlington, and thence by rail to Middlebury station. This is brought partly in lumps, which are crushed and washed at the forge, and partly dressed to a high degree of purity, and ready for use.

Overman is, so far as I am aware, the only writer who has given any account of the American bloomary process. In his "Treatise on Metallurgy" (sixth edition, 1868, page 541), will be found a description, accompanied by figures. My own observation, as here given, have enabled me to verify the general correctness and trustworthiness of Overman's statements with regard to this subject.

The bloomary hearths or furnaces in different localities exhibit some little variations in size and in the details of their arrangements. The size of the hearth varies from 27 by 30 to 28 by 32 in., and the height, from 20 to 25 in. above the twyer, and from 8 to 14 in. below. The sides are made of heavy cast-iron plate, and the bottom, although often of beaten earth or cinders, is, in the best constructed hearths, also of iron, made hollow, and kept cool by a current of water, which is made to circulate through it. In the East Middlebury forges this bottom-plate is 4 in. thick, and has within it a hollow space of 2 in. The side-plates, which slope gently inwards, in descending, and rest on ledges on the bottom-plate, are 1¼ in. thick. A water-box, measuring 12 by 8 in., is let into the twyer-plate, and a stream of cold water circulates through this box, and through the bottom-plate, as well as around the twyer. The length of the hearth, from the twyer-plate to that opposite, is 24½ in, and the breadth from front to rear is 29 in. The twyer enters 12 in. above the bottom, and is in-

clined downwards at such an angle that the blast would strike the middle of the hearth. The opening of the twyer has the form of a segment of a circle, and is 1 in. high by $1\frac{3}{4}$ in. wide. In front of the furnace, at 16 in. from the bottom, is placed a flat-iron hearth, 18 in. wide. The side-plate beneath it is provided with a tap-hole, through which the melted slag or cinder may be drawn off, from time to time. The iron plates used in the construction of these furnaces last for 2 years. In the furnaces used at the New Russia works in Moriah, already mentioned, the iron bottom-plate is not made use of, the bed consisting of beaten-down earth or ashes. These furnaces have a depth of 24 in., and measure 20 by 32 in. at the top, but are somewhat smaller toward the bottom; the twyer, in these, enters one of the narrower sides of the rectangle. While these are somewhat smaller than the forges at East Middlebury, those lately constructed at Moisie are somewhat larger, measuring 30 by 32 in., the bottom-plate being 14 in. below the twyer, which is placed nearly horizontal, but of the same size as that described above.

The blast employed in the American bloomaries has a pressure of from $1\frac{1}{2}$ to $1\frac{3}{4}$ lbs., and is heated by passing through a series of cast-iron tubes, placed in an upper chamber, above the furnace. These are in the form of inverted siphons, each limb being about 7 ft. in length, their exterior diameter 7, and their interior diameter 5 in. At the East Middlebury forges the air is made to pass successively through 3 such tubes, heated to dull redness, and attains a temperature estimated at from 550 deg. to 600 deg. Fahrenheit. The use of the hot blast hastens the operation, and enables the workmen to produce a larger quantity of iron in a given time, than with the cold blast, while, at the same time, it effects a considerable saving in fuel. It is said that where 240 bushels of charcoal will produce a ton of iron with the hot blast, 300 bushels of the same coal would be consumed if the cold blast were used. The quality of the metal is supposed to be deteriorated if too hot a blast is used. With judicious management, however, the use of the hot blast offers great advantages over the cold blast, and has been very generally adopted in the American bloomaries.

The working of these furnaces is conducted in the following manner: The fire being kept active, and the furnace heaped with coal, the coarsely pulverized ore is scattered, at short intervals, upon the top of the burning fuel, and in its passage downwards is reduced to the metallic state, but reaches the bottom without being melted, and there accumulates, the grains agglomerating into an irregular mass or loup, as it is termed, while the earthy matters form a liquid slag or cinder, which lies around and above it, and is drawn off from time to time through the openings in the front plate. At the end of two or three hours, or when a sufficiently large loup is formed, this is lifted by means of a bar, from the bottom, brought before the twyer for a few minutes, to give it a greater heat, and then carried to the hammer, where it is wrought into a bloom; the bloomary fire itself being generally used for re-heating. This operation concluded, the addition of ore to the fire is resumed, and the production of iron is thus kept up, with but little interruption. In this way a skilled workman will, with a large sized furnace, bring out a loup of 300 lbs. every 3 hours, thus making the produce of the day of 24 hours, 2,400 lbs. of blooms; in some cases, it is said, 1,500 lbs., and even more, are produced by 12 hours working.

In this connection may be mentioned an arrangement, described and figured by Overman, in which the waste heat from the forge (or rather from two forges united) passes into an oven or stove, placed at a level above the bloomary-fire, and there serves to re-heat the blooms, when it is required to draw them out into bars. A set of small blast-pipes, placed just above the forge, serves to heat a portion of air, which is led into the oven, and there burns any escaping carbonic oxide gas. The air and gases from the re-heating oven are afterwards employed to heat the blast for the bloomary hearth, in the usual manner. I have not seen this arrangement in operation.

The following observations will serve to give some notions of the working of the bloomary process in the United States. At the Ausable works, as already stated, the somewhat lean ores are dressed so as to yield about 50 per cent. of iron, 2 tons of ore being required for 1 ton of blooms,

while at the New Russia forges, in Moriah, near Port Henry, where a nearly pure magnetite is employed, 3 tons of the dressed ore are stated to yield 2 tons of blooms. When it is considered that perfectly pure magnetite contains only 72.0 per cent. of iron, this proportion of 66.6 per cent., said to be obtained, shows a great economy in working. These figures, furnished me by the proprietor of the forges, Mr. Putnam, were afterwards confirmed by Mr. Pearson, the director of those at East Middlebury, where the very rich ores from the same region are treated. The dimensions and construction of the New Russia forges have already been given. The pressure of blast employed was from $1\frac{1}{2}$ to $1\frac{3}{4}$ lbs., and the average produce of iron for each fire, 2,400 lbs. of bloom-iron in 24 hours; the amount of charcoal consumed being from 250 to 300 bushels to the ton of blooms produced, and the weight of the charcoal from 16 to 18 lbs. to the bushel.

At East Middlebury, where, as just stated, the conditions are very similar, the estimated consumption of charcoal was 270 bushels to the ton of blooms—a result which is the mean of the figures obtained at the New Russia forges. Some of the ores here used contain a little phosphate of lime, and it was observed that when too hot a blast was used, although the production of metal was rapid, the iron from these ores was hot-short, while with the cold blast, formerly employed, the iron, although produced more slowly, was never hot-short. The force of the blast at these forges was equal to $1\frac{3}{4}$ lbs., and even 2 lbs. to the in. Mr. Pearson, the director of the East Middlebury forges, made, in the autumn of 1867, experiments on several tons of the iron sands from Seven Islands, and succeeded in obtaining from them about three-eighths of their weight of good iron. He, however, found it necessary, in order to treat these fine sands, to reduce very much the force of the blast, an experience which has been confirmed by the practice at Moisie. It appears to be from ignorance of this fact that the bloomers of New York had always rejected the fine sandy ore separated during the process of washing, as being unsuited for treatment in the bloomary fire.

At Moisie, although eight forges have been constructed, but four of them were in operation at the time of my visit in August, 1868, and the same number, I am informed, in October last, two of the furnaces not having yet been completed. A reverberatory furnace has, since my visit, been constructed, in which it is proposed to re-heat the loups for the second hammering, instead of returning them, as in most cases is done, to the forge-fire for that purpose. The opening of the twyers used measured 1 in. by $1\frac{7}{8}$; they were inclined downwards at a very small angle, it having been found by experience that the considerable inclination which is used with the coarser ores cannot be advantageously employed with the fine sands. In like manner, as remarked above, it has been necessary to reduce the force of the blast, to from $\frac{7}{8}$ to $1\frac{1}{4}$ lbs., the average working-pressure being about 1 lb. to the in. According to the latest accounts, there were, in October, 4 hearths in regular operation, requiring 4 bloomers, 1 assistant to furnish coal, etc., and 1 hammerer, being 6 men in all for each shift of 12 hours. Each hearth furnished 8 loups daily, and the aggregate yield of iron was estimated at 3 tons, or $\frac{3}{4}$ of a ton for each earth every 24 hours. The consumption of charcoal was 1,400 bushels daily, being at the rate of 466 bushels to the ton of blooms, or 350 bushels to each fire. This charcoal is chiefly produced from spruce and fir, with some admixture of birch, the wood being mostly small, and the weight of the coal is stated to be 15 lbs. to the bushel. This gives a consumption of 6,990 lbs. of charcoal for the production of 2,240 lbs. of blooms, being at the rate of 3.12 lbs. of charcoal for the pound of iron. If we compare this result with the figures given above, for those forges which treat nearly pure magnetic iron ores, we find that to produce a ton of blooms there are consumed, at East Middlebury, 270 bushels, and at New Russia from 250 to 300 bushels of charcoal, weighing from 16 to 18 lbs. to the bushel. If we assume, in both cases, the greater weight, of 18 lbs. to the bushel, we have for 250 bushels, 4,500 lbs., and for 300 bushels, 5,400 lbs. of charcoal, the former corresponding to 2.01 lbs., and the latter to 2.41 lbs. of charcoal to the lb. of iron; or, taking the mean of the two, 2.21 lbs., as compared with the 3.12 lbs. said to be consumed at the Moisie works.

If now, we consider the relative sizes of

the different bloomary hearths, we find them to be as follows :—

New Russia.......	20 × 32 in.	= 6,400 sq. in.
East Middlebury..	24 × 29 "	= 6,960 "
Moisie............	30 × 32 "	= 9,600 "

The area of the Moisie hearths is, then, in round numbers, $1\frac{1}{2}$ times that of the others, and, with an equally powerful blast, they should consume $\frac{1}{2}$ more charcoal. This increased size is, however, counterbalanced by the feebler blast, and we find that each fire at Moisie consumes, in 24 hours, 350 bushels of charcoal, equal to 5,250 lbs., which, from the calculations already given for the New Russia forges, should produce, with an ore such as there treated, 2,375 lbs. of iron. In fact the Moisie forges, according to the data before us, with an area $\frac{1}{2}$ greater, consume daily the same weight of charcoal as those of New Russia, and produce only $\frac{2}{3}$ as much iron.

I have recently been informed that, with careful management, it has lately been found possible so far to reduce the consumption of fuel at Moisie, that a ton of blooms can be made with 350 bushels of properly prepared charcoal. The consumption of ore, which formerly amounted to 3 tons or more for a ton of blooms, is also said to have been considerably reduced, the daily production of iron from each hearth, however, remaining the same as before.

The cause of this small production of iron, as compared with the area of the furnace, and with the consumption of fuel, is not, in my opinion, to be found either in the reduced force of the blast or in the mechanical condition of the ore. A great heat is not required for the reduction of the oxide of iron to the metallic state, and other things being equal, the finer its subdivision, provided it be not dissipated by the blast, the more rapid and more complete should be its conversion to the condition of metal, by the action of the reducing gases, as it passes downward through the mass of burning charcoal. Such coarse grains of ore as pass, incompletely reduced, through the ignited fuel, and in this state reach the slag below, have no chance of further reduction in the forge. Hence we may conclude that the fineness of the ore should, under favorable conditions, render the reduction more complete.

The principal cause of the small yield of the Moisie furnaces is apparently to be found in the incompletely purified condition of the ore. It will be seen that the iron sand, as now prepared for the forge, may, by the use of the magnet, be divided into two nearly equal portions. One of these is magnetic, and consists, for the greater part, of magnetic oxide ; it contains over $\frac{2}{3}$ its weight of iron, and is nearly equal in richness to the magnetic ore used in the New Russia forges. The other half is a highly titaniferous oxide, mixed with more or less silicious matter, and containing only 44 per cent. of iron ; and its admixture with the magnetic oxide, which reduces the proportion of iron in the whole to 55 per cent., appears to be not merely useless, but actually prejudicial.

When an impure ore of iron is treated in the blast-furnace, certain substances called fluxes are added, which form fusible combinations with impurities. Thus, if the ore contain silica, a sufficient quantity of lime is smelted with it, and a silicate of lime is formed, while the oxide of iron, being left free, is wholly reduced to the metallic state. In the direct method, on the contrary, no fluxes are used, and if silica be present in the ore, it combines with a portion of the oxide of iron, forming a silicate of iron, which melts into a slag or cinder, from which the iron cannot be separated in the forge. Thirty parts of silica will, in this way, unite with 72 parts of protoxide of iron, equal to 56 parts of metallic iron. In the case of the somewhat silicious ores of the Pyrenees, treated in the Catalan forge, we have seen that $\frac{3}{10}$ of the iron present in the ore pass into the slag, and the loss would be much greater did not these ores hold a considerable proportion of manganese, lime and other bases, which help to satisfy the affinity of the silica, and to leave the iron free. Such substances as these play the part of fluxes with a silicious ore, but if they are wanting, a portion of the oxide of iron itself is consumed for the purpose, forming, in fact, the only flux for the silicious impurities, when such an ore is treated by the direct method in the bloomary fire. Whenever, in the Catalan forge, the American bloomary fire, or any other direct method, we have to treat an ore containing free silica, provided other bases are not present, we must always

allow oxide of iron in the proportion already indicated, for the saturation of the silica, being at the rate of nearly 2 parts of metallic iron for each part of silica present in the ore. It is for this reason, it may be remarked, that kiln-burned charcoal is to be preferred, for the bloomary hearth, to charcoal made in the piles; the latter being generally more or less impure from adhering silicious earth, which, by combining with the oxide of iron, causes a waste of the ore.

The quartzose sand which is mixed with the iron sands, is nearly pure silica, and the oxide of titanium which they contain, appears, from the analyses of slags given below, to require, for fluxing it, as much oxide of iron as the silica itself. These slags, in case no other bases than oxide of iron are present, should approach very closely to the composition of a tribasic silicate of protoxide of iron, which, as already explained, contains 30 of silica to 72 of protoxide of iron, or 29.40 per cent. of silica, and 70.60 of protoxide, equal to 54.9 per cent. of metallic iron. The highly titaniferous slags produced at the Moisie furnaces contain, in some cases, a still large proportion of oxide of iron.

Of the following analyses, I is of a crystalline, black, brilliant magnetic slag, which contained cavities lined with large pyramidal crystals, apparently dimetric in form. It was produced at the Moisie forges in the autumn of 1867. II was a portion of the ordinary slag produced at the time of my visit, in August, 1868, and was similar to the last, but somewhat vesicular, the cavities being lined with very small brilliant crystals. Both of these slags readily gelatinized when treated, in powder, with hydrochloric acid. The residual silica, however, showed a portion of grains of undecomposed ore, which was larger in the second specimen; it was in each case deducted from the analysis. The whole of iron in both of these slags is represented as protoxide, and the results are compared with those of two analyses of the non-magnetic portion of the ore, copied from pages 267 and 268, and here given under III and IV:

	I.	II.	III.	IV.
Peroxide of iron	67.14	52 31	58.20	56.38
Oxide of manganese	undet.	2.04	.....	1.10
Lime	1.37	.....	.....	.95
Magnesia	.80	.18	.....	.....
Alumina	.....	.56	.....	.....
Titanic Acid	20.07	34.05	30.74	28.95
Silica	8.75	11.29	6.14	8.75
	98.13	100.42	.....	.....
Metallic Iron	52.22	40.68	45.26	43.85

From a comparison of the above analyses it will be seen that the first slag contains more oxide of iron than the non-magnetic portion of the ore; which, in the conditions of working, at the time the slag was produced, actually dissolved and carried away a considerable portion of the reducible ore. If we were to regard one-half of the washed ore as composed of pure magnetic oxide, this, were it wholly reduced, could only yield an amount of metallic iron equal to 36 per cent; but the magnetic ore, as we have seen, still retains more than 6 per cent of silica and titanic acid, which must be removed by fluxing with a portion of the oxide of iron present, giving rise to a certain amount of slag. Meanwhile the non-magnetic ore, in melting, removed another portion of iron oxide, so that when this slag was made, more than three tons of a mixed ore, having the composition above given, must have been consumed for the production of a ton of blooms; while, of the magnetic portion of the ore, one and a half tons, or a very little more, would suffice. (In the production of slag II the loss of iron was somewhat less.) This explains why the Moisie furnaces have yielded, when compared with those of New York and Vermont, so small an amount of iron for the labor employed

and the fuel consumed. To produce a ton of iron it has been necessary to handle twice as much ore as is required in forges where a pure ore is treated, and moreover one and a half tons, or more, of worthless material have been fused and got rid of as slag, thus involving a great waste of fuel as well as of labor. It may here be remarked that a portion of slag taken by me from the East Middlebury forges, contained, according to Mr. Broome's analysis, 48.2 per cent. of iron (equal to 62.06 of protoxide), and 16.70 of silica, besides 17.33 of alumina, and 1.82 of oxide of manganese. The amount of slag produced by the rich ores which are treated at these forges, is comparatively very small.

It would seem probable that by a judicious management of the working, the waste of iron in the slags at Moisie might be considerably reduced, and this result, we are assured, has lately been attained; but it will still remain true, that a large amount of iron oxide must be consumed to flux the considerable proportions of silica and titanic acid, which are present in the mixed ore, even after careful washing.

It should here be explained that the result would be far otherwise if this ore, with all its impurities, were to be fused in a crucible with carbonaceous matters, with, or even without proper fluxes. In the former case, as in a blast-furnace, the whole of the iron which it contains, amounting to less than 55 per cent., might, by judicious admixture, be set free, and reduced; and in the latter cases, without fluxes, it has been shown by Percy, that by fusion at a high temperature, in a crucible lined with charcoal, the tribasic silicate of iron, already noticed, gives up two-thirds of its iron, which is reduced to the metallic state, so that the amount of unreduced oxide retained by the slag would be inconsiderable. From this it is evident that the results of fire-assays, or trials on a small scale in crucibles, cannot serve as a guide to the working of iron ores in the direct method.

A certain amount of lime added to the ore, would doubtless reduce the waste of iron in the slags, and thus allow more iron to be obtained from the mixed ore; but although such an addition is useful in the blast-furnace, it would require experiments to determine whether the practice could be advantageously introduced in working in the bloomary-hearth. In a region where the ore is so abundant and so cheap as it is at Moisie, the saving of iron is a consideration which should be subordinate to the economy of fuel and labor, and the most profitable way of working these iron-sands would seem to be by separating and rejecting the non-magnetic portion, by some apparatus like that described farther on.

The quality of the iron produced at the Moisie forges is superior. As the result of experiments made upon it in England, it is said to possess a tensile strength greater than that of Low Moor iron, and to work easily both hot and cold. It is now employed at Montreal for the manufacture of railway axles.

The fact that those objectionable elements, sulphur and phosphorus, occur in but very small quantities in the iron-sand of Moisie, has already been noticed. It is probably to the absence of these that the excellence of the Moisie iron is due. In a specimen taken from a bloom which was made in my presence at the Moisie forges, the presence of sulphur could be detected by delicate tests, but its amount was only .0094, or less than $\frac{1}{10000}$; while the quantity of phosphorus present was equal to .0184 per cent. This iron contained no trace of titanium in its composition, and a small mass of white crystalline cast-iron, which had accidentally been formed in one of the forges, was equally destitute of titanium.

[TO BE CONTINUED.]

Professor Kerr, State geologist of North Carolina, in speaking of Black Mountain in that State, says: "These rocks belong to the most ancient of the azoic series. The intensity of the metamorphism, the characteristic rocks and their contained minerals, together with the total absence of anything like organisms in even the least altered and latest of the series, render this conclusion inevitable. And not only do they belong to the lowest geological horizon, but the entire absence of all representatives of the latter formations makes it further necessary to conclude that we have here an extensive tract of the oldest land on the globe."

ECONOMICAL STEAM ENGINES.*

From "The Engineer."

It is at all times an ungracious task to point out the errors of those who, either from a natural perversity or from a want of accurate knowledge, persist in giving publicity to statements of a misleading character. There are, however, circumstances under which this task—ungracious though it may be—becomes a duty, and it is under what we conceive to be such circumstances that the present article is written. The readers of a contemporary of ours have been favored during the past few months with a series of articles on economical steam-engines, which must have given rise to no small amount of amusement, combined with bewilderment, in the minds of those who perused them. The main object of these articles—so far as they can be said to have any object—appears to have been to denounce the compound engine as complicated and untrustworthy; and in doing this, the writer has quoted numerous well-worn axioms, as if they were most startling and original truths, and has further taken occasion to season his compilations by descriptions of various pet schemes of his own for steam-engine improvement. Some of the earlier articles of the series just referred to, have been already criticised in our pages, and we have pointed out many of the mistatements and examples of false reasoning in which they abound. That we have allowed many of the inaccuracies contained in them to pass unnoticed, we are fully aware, the fact being, however, that we could spare neither the space nor the time that would have been necessary to correct the whole of our contemporary's errors. Even as it is, we fear we have given the subject more prominence than is acceptable to those of our readers who, being better informed themselves, can afford to laugh at the vagaries of our contemporary; but it must be remembered that these vagaries are read by numbers of the junior members of our profession, who are but too ready to accept as trustworthy all such statements and false principles as those which our contemporary thinks fit to advance, and it is in the interest of this class of our readers especially that we now write.

Last week our contemporary published what purported to be the concluding article of the series we have referred to, and in commencing this article the writer states that he proposes "to lay down a few general principles intended to serve as guides at once for the engineer making engines, and the manufacturer using steam power." Before proceeding with this very praiseworthy task, he lays down three propositions which he apparently considers to be original discoveries, and which he states he has "already endeavored to prove by argument and statement of fact." The first of these celebrated propositions is to the effect "that engines are not necessarily economical because they burn very little coal, for the construction of such engines only too often renders them liable to break down, or is certain to entail large outlays on repairs, attendance, grease, etc., which amount in the long run to more than the saving effected in coal." We can assure our contemporary that the fact that the economy of any particular engine is not to be estimated by its coal account alone, is one which was universally recognized by all competent engineers years before our said contemporary had any existence, and that any "arguments and statements of fact" which it may have brought forward to prove its pet proposition were entirely unnecessary. Although, however, our contemporary has not managed to bring forward an original proposition, it has managed to display a certain amount of originality in its method of applying the proposition to its own ends. For example, it says: "Thus, of two engines, one may burn two tons of coal a day, while another burns three tons. In the manufacturing districts coal is worth, say, 7s. a ton. The saving effected by the more economical engine is, therefore, 7s. a day. But the extra cost of grease, skilled attendance, etc., may amount to more than 7s. per day, and the apparently more economical engine will be worked at a loss." Very plausible this, no doubt, but also very inaccurate. The saving effected by a reduction of the

* See page 78, July No. of this Magazine.

quantity of coal used by one-third, is very far from being fully represented by the mere value of the fuel saved. A reduction of the consumption of coal from three tons per day to two tons, means not merely a saving of 7s., as stated by our contemporary, but it means, also, a saving of one-third in the boiler power required, of one-third in the labor of stoking, and of one-third in the amount of water required for boiler feeding, and for the purposes of condensation; this latter saving being in itself in some cases even a more important matter than the reduced consumption of fuel. On the other hand, no evidence is advanced—and, we may add, that none is obtainable—that a really well-constructed "economical" engine requires either more skilled attendance or more expensive lubrication than an engine of far less perfect construction; in fact, so far as our own experience goes, the contrary is the case. An economical engine, consuming 2 tons of coal per day, should develop at least 200 indicated horse-power, and our readers may rest assured that the cases in which a high-class engine of this power could not be employed with true economy are very rare indeed, and we, in fact, doubt their existence.

Our contemporary's second proposition is, "that it does not follow that the engine giving out the highest indicated horse-power per pound of coal burnt is the more economical, even though the cost of attendance, grease, and repairs remained unaltered, because the indicated does not represent the effective or paying horse-power, and it is this last alone which has to be considered." Now this proposition, if it means anything—a fact of which we are doubtful—means that in the more economical engine there will be a greater proportion of the indicated power expended in overcoming internal friction than is the case with its less economical rival; but it is most certainly curious that if this is the case the cost of "grease and repairs" should remain the same in the two instances. Our contemporary's second proposition, therefore, is self-contradictory.

We now come to our contemporary's third proposition, which is to the effect: "that the cost of a first-class engine may be so great as to deprive the honest manufacturer of any chance of selling." This is no doubt partially—but only partially—true. A first-class engine may be made to cost almost any sum, but by avoiding all unnecessay finish a really economical engine can be produced at a cost which is but very little in advance of that of engines of most ordinary construction. Moreover, the fact that any difficulty is experienced in disposing of high-class engines is to be attributed not to such engines not being worth the sums asked for them, but to the ignorance of their real value exhibited by those who ought to employ them. Under these circumstances it is the duty of the professional journalist not to advocate the increased production of engines whose sole recommendation is their cheapness; but rather to endeavor to open the eyes of employers of steam-power to the important advantages which they are in but too many instances sacrificing to a slight saving in first cost. That a vast number of cheap engines are manufactured and sold profitably is no doubt true; but except, perhaps, in the case of small powers or when required for temporary purposes, we know of no case in which such engines can be employed with advantage to the purchasers. This, however, is a question with which we have dealt fully in former articles, and we shall, therefore, pass on to consider some of the principles which our contemporary lays down as guides for engineers making engines.

Our contemporary makes a good start by recommending the horizontal form of engine, and by further recommending that the cylinder should be kept hot and dry. There is nothing, however, very original in these recommendations, and to atone for this want of originality apparently, our contemporary proceeds to describe an arrangement which it states is "now, we believe, proposed for the first time." This arrangement our contemporary describes, as consisting "in jacketing the steam pipe, that is to say, enclosing the steam pipe within another a couple of inches larger in diameter and carefully lagged." How many years have passed away since the time when the proposal to jacket a steam pipe would have been esteemed a novel one we are unable to state; but we venture to say, that our contemporary's notions as to how such jacketing should be carried out possess undoubted claims to originality. Lest our readers should think that we are

quizzing them, we give the description of the proposed arrangement in our contemporary's own words, which are as follows: "The pressure in this pipe [that is the jacket] would be always that in the boiler, but the pressure in the steam pipe is of necessity always a little less, and the fluid on its way to the engine would, therefore, always be exposed to a slight superheat; a small cock should, of course, be fitted to draw off the condensed water [query condensed *steam?*] from the outer pipe. The inner pipe having only the difference between the boiler and the valve chest pressures to withstand, might be made very thin, as it would always be in compression [the very reason why it should *not* be made thin, we should have thought], and the boiler stop-valve would, of course, be common to both, so that steam could not enter one without the other." It is certainly difficult to believe that such a proposition as this could have been made otherwise than as a joke, yet we find our contemporary recommending the arrangement in all seriousness as "a static improvement," and further asserting that it "would be found unlikely to get out of order and very cheap to make!" From our contemporary's description it is evident that, as the boiler stop-valve is to shut off the supply of steam to both, the steam-pipe and jacket must be in free communication with each other, and it would have been gratifying to inquiring minds if our contemporary had condescended to explain how, under these circumstances, the excess of pressure in the jacket necessary for superheating purposes was to be obtained. Further, the author of the brilliant suggestion we are considering, speaks of the inner pipe being made thin on account of its having to withstand only a slight excess of external pressure; but if he takes the trouble to refer to a table of the temperatures of steam, he will find that at the ordinary pressure at which boilers are worked, an excess of pressure in the jacket of even 5 lbs. per square inch, would give him less than 5 deg. difference of temperature, and we should like to know of what service this 5 deg. would be for superheating purposes. The whole plan proposed is, in fact, simply ridiculous, and to our contemporary's query: "If a cylinder is to be jacketed why not a steam-pipe?" we need only reply, "Read some some elementary work on the steam-engine and find out."

Next says our contemporary: "Having got dry, clean steam [we presume with the chill taken off by the beautiful arrangement above described] it remains to be seen what we shall do with it." Just so, and having read the remainder of our contemporary's article, we have come to the conclusion that this fact "remains to be seen" still, as far as he is concerned. The article contains many unsupported assertions, but no specific information, and the writer appears to have entirely forgotten that this supply of "dry, clean steam" remained to be disposed of. Thus we are informed that uncompounded engines do not do as well as compound engines, simply because the former are "not worked with steam in the condition of a perfect gas," a state of affairs which we presume the original arrangement we have alluded to is designed to remove. Further, we are informed that compound engines are "invariably compared with single engines with unjacketed cylinders:" a "fact" which, we fancy, will take many of our readers by surprise. Our contemporary also states that: "The real advantage, such as it is, of the compound engine, is that it saves the engine from shock, and equalizes the strain and driving power; but the same end can be attained in other and cheaper ways, even with large measures of expansion." What these "other and cheaper ways" may be, the writer does not condescend to explain; but we are glad to see that he does not again repeat his proposal to use enormously heavy fly-wheels, the absurdity of which we exposed in our article entitled "Wonderful Fly-wheels," which appeared in this journal a few weeks ago. Evidently the few simple statements we then made have been appreciated, and we can assure our contemporary that, actuated as we are by a desire to spread useful knowledge, this fact more than compensates us for having devoted space to the elucidation of such exceedingly elementary principles.

The subscriptions to the fund for defraying the expenses of the proposed inquiry by the British Association Committee on Sewage amount to above 12,000*l.* The inquiry will be commenced at once.

THE UNIT OF LENGTH.

From "Nature."

The battle of the Standards is over, and we may say the Metre has gained the victory. The need of a new system of weights and measures to amend the strange diversities which disfigure our practice being admitted, the question has once more been started—Should we once for all found our system on a natural basis? The pendulum vibrating seconds in a certain latitude, was long ago proposed as a universal basis of linear measure, and the House of Commons somewhat countenanced it years ago, by prescribing that the length of the yard shall be determined by the length of the second's pendulum. But the action of gravitation, on which the terms of the vibration depends, is subject to so many variations and disturbances, that the quantity sought cannot, even on the same spot, be absolutely the same at all times. The real length of a normal pendulum is almost unattainable, so limited is our knowledge of the force of gravity on land and at sea. A more certain basis for a natural unit has been found in the polar axis, the length of which, according to Sir John Herschel, bears a close relation to our imperial inch, and has the advantage of avoiding the many causes of error resulting from the physical peculiarities of the countries through which any measured arc may happen to pass. But are our physicists agreed as to the real length of the polar axis, and would it be worth while to make any alteration in our weights and measures for the sole purpose of attaining some scientific correspondence between the unit in use and a unit founded on nature?

The advocates of the metre rest their arguments on a much broader basis. They do not assert that the metre is absolutely and mathematically the ten millionth part of the quadrant of the earth; they know that the meridians of places differing in longitude are not all precisely of the same length; and they admit that were we now to make a new measurement with our better instruments and more extended information, we might attain much greater accuracy than was arrived at by the French philosophers at the end of the eighteenth century. What commends the metre above any other unit, is the fact that it is already a cosmopolitan unit, widely recognized, and in general use among many nations; and that whilst other units remain as philosophical abstractions, the metre is the basis of a system, not only perfectly complete, homogeneous, and scientific, but simple and practical in all its parts. Any slight error in the determination of the metre, is more than counterbalanced by the extreme simplicity, symmetry, and convenience of the metric system; and not the least of its recommendations are, that the unit of linear measure applied to matter in its three forms of extension, viz., length, breadth, and thickness, is the standard of all measures of length, surface, and solidity; and that the cubic contents of the linear measure in distilled water at a temperature of great contraction, furnish at once the standard weight and measure of capacity.

When we said that the battle of the Standards is over and that the Metre has gained the victory, it was meant that, for practical purposes, all opposition to the introduction of the metric system has been abandoned, and that Parliament and the Government are now left to introduce it in such a way and at such a time as may be found at once practicable and satisfactory. The use of the metric system has been legalized for the last half-dozen years, but it was not till quite lately that the whole question was submitted to the calm deliberation of a Royal Commission. The Standard Commissioners, who included among their members the Astronomer Royal, the President of the Royal Society, and the late Master of the Mint, considered the question of the introduction of metric weights and measures, in any form, *ab initio*. And after careful examination they gave their verdict in its favor in the following terms:—

"Considering the information which has been laid before the Commission—

"Of the great increase during late years of international communication, especially in relation to trade and commerce;

"Of the general adoption of the metric system of weights and measures in many

countries, both in Europe and other parts of the world, and more recently in the North German Confederation and in the United States of America ;

"Of the progress of public opinion in this country in favor of the metric system as a uniform international system of weights and measures ;

"And of the increasing use of the metric system in scientific researches and in the practice of accurate chemistry and engineering construction ;

"We are of opinion that the time has now arrived when the law should provide, and facilities be afforded by the Government, for the introduction and use of metric weights and measures in the United Kingdom."

The Commissioners further recommend that metric standards, accurately verified in relation to the primary metric standards at Paris, should be legalized ; that verified copies of the official metric standards should be provided by the local authorities for inspectors of such districts as may require them; and that the French nomenclature, as well as the decimal scale of the metric system, should be introduced in this country. The Commissioners, whatever might have been their predilections, could not resist the fact that the civilized world pronounced itself for the metre, and they sanctioned its legalization. What is to be regretted is that they stopped there. Since the complete substitution of the metric for the present practice is now practically certain, would it not be much better to prepare for the change and carry it into effect as speedily as possible ? No advantage can come from a policy of indecision, and we trust that the Legislature may adopt a more definite course than the one sketched out by the Royal Commissioners. Let it not be imagined that the people will give themselves the trouble of learning the new system, however beautiful and easy, so long as its use is not absolutely necessary. With all the desire of the teachers to introduce it in the schools, they find that they cannot teach the old and the new tables. They cannot afford the time. A compulsory measure is the only method of dealing with the question.

The Warden of the Standards being now employed in procuring Metric Standards, it may be well to add that the mode of constructing them, either from the original Metre at the Archives, or from the copy at the Conservatoire des Arts et Métiers, has been much debated. The International Statistical Congress, held at Berlin, decided "That the care of preparing and putting into execution the regulations to be followed in the construction of the standards, and of the system itself, should be intrusted to an International Commission, which will also see to the correction of the small scientific defects of the system." The International Geodesical Conference, held at Berlin in 1867, decided : "In order to define the common unit of measures for all the countries of Europe, and for all times, with as much exactness as possible, the Conference recommends the construction of a new prototype European Metre. The length of this European Metre should differ as little as possible from that of the Metre of the Archives in Paris, and should in all cases be compared with the greatest exactness. In the construction of the new prototype standard, care should be taken to secure the facility and exactness of the necessary comparisons." And "the construction of the new prototype metre, as well as the preparation of the copies destined for different countries, should be confided to an International Commission, in which the States interested should be represented." Since then, the Imperial Academy of Science of St. Petersburg has taken the matter in hand, and a committee of the Physico-Mathematical class, consisting of MM. Struve, Wild, and Jacobi, has made a report on the subject, observing that the standard metric weights and measures of the various countries of Europe and of the United States differ by sensible though small quantities from one another. They expressed their opinion that the continuation of these errors would be highly prejudicial to science. They believed that the injurious effects could not be guarded against by private labor, however meritorious, and they recommended that an International Commission should be appointed by the countries interested to deal with the matter.

According to M. Saint Deville, the oxygen dissolved during the fusion of platinum causes the metal to spirt as in the case of molten silver.

THE CHEMICAL TREATMENT OF SEWAGE.

From "The Mechanics' Magazine."

In whatever manner the removal of sewage from the vicinity of habitations and dwellings may be effected, there yet remains the subsequent utilization of it to be accomplished before it can be said that this great national question has been dealt with commensurately with its extent and importance. One of the primary objects to be insured, except where irrigation is made use of, is its purification. Various plans have been devised, patented, and experimented upon with this end in view, some of which have been partially successful, but not a single one can be candidly said to have fulfilled all those conditions necessary to constitute a perfect success. At present we propose to consider those plans for the purification of sewage which adopt as the basis of their treatment the employment of chemical reagents. What is aimed at by the chemist is the extraction, conversion, and production of an artificial fertilizer. He is well aware that all the elements of a valuable manure exist in sewage, and he is therefore anxious to treat it in such a manner as to cause it to yield a really fertilizing manure in a portable, a marketable, and a remunerative form. As yet very little success has attended these efforts. The estimate of the valuable properties of artificial manure manufactured from sewage which is formed by the chemist has hitherto been enormously in excess of that which is put upon it by the practical farmer and agriculturist. The latter being the purchaser and consumer, his estimate of it is the one which finally settles the question respecting its real utility and value. It is obviously to no purpose for a chemist or an analyst to put a certain theoretical value upon a product or manufactured article which it fails to possess in practice, if, as is the case, the cost of its production is to be defrayed out of the sum for which it sells. In all similar operations preliminary experiments are indispensable to arrive at a correct estimate of the result, but a time must come when the experiments must cease and some tangible return be made for the outlay incurred. A large amount of unproductive capital has been already sunk in vain endeavors to accomplish the production from sewage of a salable artificial manure, and rate-payers and local boards naturally object to risk the loss of further sums.

In the purification of sewage the object is to extract from the fluid medium the offensive and noxious ingredients which are contained in it, and which are also the valuable components for the manufacture of an artificial manure. These ingredients may be divided into 2 classes, those which are chemically dissolved in the fluid, and those which are merely mechanically suspended in it. The former of these are the most rich in manurial properties. They consist of the various forms of combined nitrogen with a variable proportion of phosphoric acid. The relative value of the 2 classes of ingredients is readily seen from the fact that in 100 tons of sewage, the disolved constituents are worth 15s., while those held in mechanical suspension are not worth more than 2s. Manifestly, when we regard the great disproportionate value of these 2 principal components of sewage, the efforts of the chemist are chiefly directed towards effecting the extraction of the former. Moreover, it is in this particular that lies the main difficulty. Mechanically suspended substances are easily removed by filtration, but as they do not contain more than a seventh of the real fertilizing ingedients, it is clear that they would never repay the cost of their extraction. There is another point to be attended to with respect to the chemical treatment of sewage, besides that already mentioned, of manufacturing a manure from it. It is the rendering of the residue or effluent water sufficiently pure to allow it to be discharged into the nearest river or watercourse of the country. It is very questionable whether this has been practically effected by any method save that of irrigation, although there is no doubt that many of the processes in use, or under experiment, do purify the water to a considerable extent. The removal of the suspended matters alone does not effect an adequate purification of sewage water, since the dissolved impurities contain most of the offensive and putrescible ingredients in more than sufficient quantity to cause a nuisance. If a

genuine salable manure were once produced there is no doubt that, as a necessary consequence, the effluent water would be purified to a degree that would permit of its being discharged into rivers and streams without fear of pollution. The reason of this is plain ; as it is only by the extraction of the noxious and offensive ingredients that a good fertilizer can be produced from it, it is similarly only by their removal that the effluent water becomes purified. The one is an inevitable result of the other.

Among the various processes that have been tried, and some of which are in present operation, may be mentioned the "lime" process, that of Sillars (also called the A B C process), that in which lime is used in combination with chloride of iron, that of Holden, and one or two others in which sulphate of alumina, sulphate of iron, coal dust, and other ingredients are employed. With respect to these chemical treatments it cannot be said that any of them have proved wholly successful, neither can it be said that they have all eventuated failures. Some certainly have been demonstrated by experiment and analysis to be totally inadequate to produce either a salable manure or to purify the effluent water to an extent that will allow it to be discharged into streams without fear of pollution. From the experiments conducted at Leicester by the Rivers' Pollution Commissioners the following very important results in connection with the two processes of the "lime" and the A B C were arrived at. The lime process considerably reduces the amount of dissolved impurities in sewage, while by Sillars' process these impurities are markedly increased. Both processes diminish the amount of organic carbon, and this is effected by the A B C treatment in a more complete manner than by that of the lime. The chief dissolved constituent of sewage that constitutes the most active element in the pollution of watercourses is the nitrogenous organic matter. This is the ingredient that becomes putrescent with the greatest rapidity, which it is most essential to remove. Both processes "signally fail" to remove this element of pollution to a degree that would render the effluent water fit to be discharged into a river. At the same time the sewage is purified by both to a certain extent, and it is possible that a further improvement may yet take place. Regarding the other question of the production of a salable manure, the superiority lies with the A B C process, which, notwithstanding that there is a loss of nitrogenous organic matter, "yields a solid manure of much greater value than that obtained by the lime process." Their separate values are per ton £1 13s. 0$\frac{3}{4}$d. for that manufactured by the Sillars process, and 13s. 6$\frac{1}{4}$d. for the product yielded by treatment with lime. Notwithstanding this difference in monetary value, the A B C process "fails to extract from the liquid more than a very small fraction of its valuable constituents." This might be anticipated from the price per ton, for were the manure rich in fertilizing properties it would fetch considerably more money in the market. It is also clear that if the cost of manufacture be deducted from this sum it cannot leave much of a balance on the credit side, even if it does not come out on the wrong page of the ledger.

A process in which sulphate of iron, lime, and coal dust are used is known as Holden's process, and has been tried in Bradford. Similarly to its rivals, it separates the whole of the suspended matter, but there its advantage appears to end. A very curious effect is produced by this treatment upon sewage, and one which is particularly worthy of notice, as it proves that it is quite possible to increase the noxious and offensive features in sewage by a so-called purifying operation. This process "not only fails to remove the putrescible organic matters in solution, but actually increases their quantity. The effluent water could not therefore be admitted into rivers without causing pollution." Since this process only extracts the suspended constituents of sewage, the manure formed from it cannot have any considerable fertilizing powers, as the suspended matters contain only about $\frac{1}{7}$ of the valuable qualities possessed by those held in solution. From these facts, which may be regarded as incontrovertible, it is manifest all these processes appear to be tending in the right direction; but, possibly from the comparatively small amount of actual experience they have undergone, the means to their ends are not yet properly organized and comprehended. It would be unfair to expect that so great a problem as the disinfection and deodorization of

sewage, together with the subsequent purification of the effluent water, could be possibly accomplished all at once. Each step towards that result must be a question of time; but whenever that step is gained it must be borne in mind that it is gained for ever. Irrigation certainly solves the problem, as no artificial mixture and combination will ever prove so thorough a purifier of sewage as the natural absorbent and assimilating powers bestowed upon the soil and plants. In many instances irrigation works assume proportions that frighten the boldest speculator, and the difficulty must be met in the interim.

ORIGIN OF GOLD NUGGETS AND GOLD DUST.

By ANDREW MURRAY, F.L.S,

From "The Scientific Opinion."

The origin of gold nuggets and gold dust is not so simple or clear as at first sight it appears to be. The natural explanation of the production of gold dust is that it is the golden portion of the *debris* of rocks which have originally had gold disseminated through them. As the wear and tear of ages has crumbled into dust mountains so composed, part of the dust becomes sand or quartz, or whatever else the basis of the rock may be, and the other part is the liberated gold from which the quartz has been rubbed away; and if we accept this as the explanation of the production of gold dust, the same hypothesis should explain that of gold nuggets which are found associated with it.

But there are various circumstances which it is difficult to reconcile with this theory. One of these is the occurrence in the drift of nuggets of a larger size and less intermixed with foreign substances than have yet been discovered in any quartz reef; as most people are aware, the gold in reefs is usually disseminated in particles and strings through the quartz veins or rock, instead of lying in pockets or masses. Another still more remarkable fact, applicable both to gold dust and gold nuggets, is that alluvial gold is generally of a higher standard than that obtained from the reefs. It is needless to say that if it is merely the gold washed or crumbled out of these reefs, it ought to be of identically the same standard and quality. Another objection to the dust being merely the degraded particles released from the rock is the size of the particles—not nuggets, but particles of dust. Gold being so much softer than quartz, its particles after being subjected to the same degree of attrition ought to be vastly smaller; although of greater toughness than quartz, and possessed of ductility and tenacity which quartz wholly wants, it is very soft, and, under the influence of the attrition from running water and its accompaniments, ought to be pounded and torn into the minutest fragments; but this is not so. There is, moreover, a marked difference in the appearance of the gold dust from different drifts in different countries. In some it is like dust or sand, in others it is like scales. If subjected to the same influences in all, there seems no reason why the same shape should not obtain in all.

These peculiarities would suggest that some other influence than mere degradation of gold-charged rocks has been the agent in producing gold dust; but in any and every view we think it cannot be disputed that degradation must have had some share in the work. It is plain that if a gold-charged rock is reduced to gravel, sand, or powder, particles of gold of some size or other, or gold in some shape or other, must form part of the *debris*. These gold remnants should be found in greater quantity and in greater size the nearer they lie to the source from which they were drawn; and this we believe also to be the case. The general similarity between gold-producing districts, by which a Californian miner could detect a likely spot for gold in Australia or Kildonan, probably depends rather on the character of the mountains out of which the gold has come than on the mode of production of the manufactured dust, if we may call it so. We imagine that the truth will be found to be that the result is referable to two causes, only one of which may in some cases have been present, in others both;

the first, the ordinary process of degradation and grinding the rock to fragments ; the other, as suggested by Mr. Selwyn, the Government geologist of Victoria, that gold has also been taken up in solution by the water permeating the gold-bearing rocks, and that in passing through the drift, in which minute particles of gold lay, it has from some cause become decomposed, and the gold held in solution been precipitated and deposited around the most congenial nuclei presented to it, which would undoubtedly generally be the particles or pieces of reef gold, or any other metallic substances for which it had an affinity.

We find an interesting paper on this subject in the "Transactions of the Royal Society of Victoria" (1867), by Mr. C. Wilkinson, in which he mentions some facts bearing on the subject. It appears that Mr. Daintree, formerly of the Geological Survey of Victoria, had on one occasion prepared for photographic uses a solution of chloride of gold, leaving in it a small piece of metallic gold undissolved. Accidentally, some extraneous substance, supposed to be a piece of cork, had fallen into the solution, decomposing it, and causing the gold to precipitate, which made a deposit in the metallic state, as in the electro-plating process, around the small piece of undissolved gold, increasing it in size to two or three times its original dimensions. Considering this accidental experiment of Mr. Daintree's as in some measure supporting Mr. Selwyn's theory, Mr. Wilkinson followed it up by a few simple experiments in the same direction, which he details in his paper. In his experiments a small chip of wood was generally used as the decomposing agent. In one instance he used a bit of leather. All through the wood and leather, gold was disseminated in fine particles, and when cut through, the characteristic metallic lustre was highly reflected. From various experiments it would appear that organic matter is the necessary chemical agent for decomposing a solution of the chloride of gold in order to precipitate the gold as a coherent coating around a nucleus ; and that, so far as Mr. Wilkinson had yet tried, iron, copper, and arsenical pyrites, galena, antimony, molybdenite, blend, wolfram, and metallic gold constitute essentially favorable nuclei to determine this chemical reaction. It is to be observed, too, that organic substances, such as fragments of wood, roots of trees, etc., occur abundantly in the gold drifts of Australia. If water holding gold in solution circulates through the rocks and drifts, all the conditions necessary for the production of gold dust and nuggets by deposit are present. Does the water so circulating now hold gold in solution? One would think it would not be difficult for a chemist in Australia or California to determine the fact by direct experiment, but it does not appear that it has ever been tried. Mr. C. Wilkinson, however, quotes facts which lend probability to the view that when the trial is made, the question will be solved in the affirmative. In testing a solid mass of iron pyrites, Mr. Daintree found gold throughout. This mass retained the structure of a tree-stem, in which the organic structure was replaced by pyrites. It had been taken from the Ballarat drift, and the same experiment was repeated by Mr. Newbury, the Geological Survey analyst, on another stem taken from the same drift, with a like result. Gold in such deposits assumes a mammillary form, which appears analogous to that presented by the surface of nuggets—a point of some importance, for, in the first place, it is a question whether a mammillary surface is the kind of surface that would be produced by abrasion and attrition ; and, in the next place, abrasion or attrition can certainly have nothing to do with its appearance in these golden petrifactions. We cannot avoid attaching the greatest importance in relation to the question, to the presence of gold in pyrites that has been formed in wood imbedded in auriferous drifts. The gold *must* have been in solution when so deposited, and everything will then depend on the age of the so petrified wood. If contemporaneous with the drift, the question is answered. Another fact to the same effect is, that sometimes gold incloses a nucleus of brown iron, etc. This is obviously quite inconsistent with such pieces of gold having been abraded, as they are out of crumbling rocks ; such nucleated pieces of gold are never found in reefs. It is the old puzzle of a reel in a bottle.

In relation to this we may remark that we believe that nuggets have never been found in the gold-fields of Brazil. We have the authority of Mr. Harding (a

gentleman well known for his great practical knowledge of gold mines and mining in that country) that he never met with nor heard of a nugget properly so called in all his many years' experience in the gold district of Brazil ; but, on the other hand, it is there almost invariably found in veins in connection with, or in the vicinity of, some other metal—generally iron. In what is probably the most prolific mine of gold that has ever been known in the whole world, that of San Juan del Rey (the value of which was not very long since so seriously depreciated by the accidental destruction by fire of the wooden ladders, supports, and machinery), the gold is found in a matrix of porous iron or agglutinated iron sand called Jacotinga, which consists of a bed or vein, not a foot in width, but so incredibly rich that on one occasion, when our informant was on a visit to the manager, there was brought in on an assiette, as a sort of dessert for the eyes after dinner, a lump of gold ore that had been extracted that day from the mine. It was about the size of a large fowl, not so big as a turkey, but bigger than a duck. It was a mass of Jacotinga-iron with gold all mingled and streaked through it. The gold when afterwards extracted was found to amount to 30 lbs. weight. On the previous day the amount of gold obtained from the Jacotinga had been 67 lbs., and on the day following 130 lbs., equal in value to about £8,000. We only mention it as a corroborative instance of the concurrent presence of gold and iron. Lastly, as pointed out by Mr. Wilkinson, it must be admitted that the fact that gold may be greatly purified by dissolving and reprecipitating it, is very suggestive of the generally higher standard of alluvial over reef gold being due to a similar cause.

EXTRACT OF TAR AND PRODUCTION OF PARAFFINE, Etc., BY MEANS OF STEAM.

From "The Engineer."

A long series of experiments has been carried on in Germany with the view to a more economical mode of extracting essences from lignite, and M. Ramdohr has given an account of his process by means of superheated steam.

His superheater for an apparatus of 8 or 9 tons, consists of a number of drawn iron tubes, rather more than $1\frac{1}{2}$ in. in diameter, and placed in three parallel rows ; the tubes are placed rather more than 1 in. apart, and those in the middle alternate with those of the upper and lower tiers, so that the flame must act on all sides of the tubes, the joints and ends of which are protected from the direct action of the fire. There is a difference of 2.5 to 2.8 atmospheres in the pressure of the steam at its entrance and exit from the superheater. The flame acts upon the tubes from above downwards, so that the heat attacks first those tubes which contain the cooler steam. Tubes made of iron $\frac{3}{8}$ in. thick will last about 8 or 9 years, and with a thickness of $\frac{1}{2}$ in. rather more.

The extractor is a cast-iron chest from 70 in. to 7 ft. long, 3 ft. to 3 ft. 8 in. wide, and 3 ft. to 4 ft. high ; at a short distance from the bottom is a sort of grate, upon which the coal is laid to a depth of 24 in. to 40 in. ; at the upper part is a tube large enough to allow of the escape of the vapor of the tar and steam through a valve into the condenser. In the front of the chest are three rectangular openings, each nearly 30 in. wide, but of different heights ; the first of these is beneath the grate, and serves to remove any pieces of coke which may fall through ; the second is level with the grate, and serves to feed the fire and withdraw the coke ; and the third is level with the upper layer of coal, most of which is introduced by this orifice. All three are luted with clay.

The superheated steam is introduced below the grate, and gradually traverses the whole mass of coal.

The apparatus now in use contains about 8 tons of lignite of Aschersleben, but M. Ramdohr is constructing one to contain 20 tons, and so arranged as to act with the smallest quantity of water possible ; he hopes with this to treat at least 9,000 tons of lignite per annum.

The condenser is peculiar in form ; it consists of two ordinary tubes united to

each other by a large number of others; one of the former is completely surrounded by a small quantity of water, while the other is in contact with the air. The vertical tubes pass through a closed iron case measuring nearly 7 ft. in length, and over 2 ft. in width and height; this case stands in an open vessel, a space of 3 in. between the two, which is also the diameter of the vertical tubes.

The tubes and this intermediate space are filled with water constantly flowing upwards, and the space between the tubes and the case is in communication with the distilling apparatus, the steam and the vapor of the tar passing in the reverse direction to the water, viz., from above downwards. The water enters the condenser at a temperature of 50 deg. to 60 deg. and leaves it at about 194 deg. Each operation requires 12 or 13 hours, including the mounting of the apparatus and the collection of the products.

By simple arrangements the progress of the operation may be observed at any moment, and in each portion of the apparatus, so that the coke is never withdrawn until it is exhausted; this is effected by means of bag-like projections on the tubes provided with small stopcocks. During the first two hours after the superheated steam is let in, nothing is disengaged but the humidity contained in the mineral, and consequently the stopcock only gives forth water; presently the tar appears in the form of a thin stratum of dark olive or coffee color, which goes on increasing until towards the end of the operation, when it falls off, and is finally replaced by a mass of flocculent yellow matter.

All the liquid products of distillation are received in the same vessel, but the water separates itself and is drawn off from below by means of a siphon, while the tar runs off by a cock. The yield of tar varies between 19 kilos. and 21 kilos. for every 150 kilos. of lignite. The cost of producing 1 cwt, of tar clear of water is about 6s. 8d. with coal at 54 cents. the 3 cwt., but with coal at 42 cents the expense is not more than 5s.

The tar, as it is called, obtained by this process, is very different from that obtained by retorts; it solidifies at 130 deg. to 140 deg., so that even in summer it is kept in the open air in great cakes between 4 ft. and 5 ft. long, and 4 in. thick, and these cakes are often stacked one on the other. The specific gravity at 194 deg. is 0.875. Its chemical composition differs much from ordinary coal tar.

According to the inventor's theory the object of distillation is not to disengage the paraffine and the crude oil from the lignite, but that which serves as the basis of the preparation of paraffine. To obtain tar, distillation is necessary, and each distillation of substances already rich in paraffine gives rise to separations without disengagement of carbon. Tar which already contains paraffine and crude oil gives rise at a first distillation to a separationof these substances, but tar which does not contain these carburets ready formed, but which includes the resin, which is the true source of paraffine, will lose much less paraffine in a well-conducted first distillation, because this substance is not, in fact, formed until the tar has reached its boiling point.

There is a very simple method of ascertaining if a given sample of tar is true tar; that is to say, a pure vegetable resin, or a mixture of resin with crude oils and raw paraffine; true tar has the properties of an acid, and will combine with alkalies, and undergo saponification, properties which the neutral bodies, mineral oil and paraffine, do not possess. Gas tar will saponify only partially when treated with caustic alkali or soda lye, about 80 per cent. of the whole separating and floating in the tar-soap; the former consists of crude oil and raw paraffine, which are found in large proportions, because in the retort the tar which is disengaged from the carbon has already submitted to partial decomposition. In good tar obtained by means of superheated steam nothing of this sort happens, it contains no trace of paraffine or crude oils ready formed. M. Ramdohr believes that the value of tar is not so clearly indicated by specific gravity as by the absence of hydrocarbons in the liquid or solid state.

Down to 1868, M. Ramdohr treated the tar in the following manner:—It was distilled and the product first washed and then acidulated; the mass thus produced, was then submitted to a first fractional distillation, the oils were immediately rectified over soda without any other chemical treatment, and the mass of paraffine crystallized. The oils, rich in paraffine, which were obtained from this substance

by pressure, were collected in the ordinary manner and crystallized as often as necessary. By this process he obtained very fine paraffine, the average of 6 years' working being 15 per cent., namely 10 per cent. at the first distillation at a temperature of about 129 deg. or 130 deg., and 5 per cent. by two subsequent distillations at a heat of 100 deg. to 118 deg. The oils formed about four-tenths in weight of the tar treated. Further experiments enabled him to obtain fine paraffine by a single distillation of tar, but this required too much time; finally, he discovered the new method of treatment which he has employed for a year or more with successive improvements. The average of 9 months' working gave him 22 per cent. to 24 per cent. of paraffine, 15 per cent. obtained at between 133 deg. and 137 deg. or 138 deg., and 7 per cent. to 9 per cent. of secondary product obtained between 100 deg. and 118 deg., with 36 per cent. to 38 per cent. of oils of all kinds. He hopes to obtain from tar extracted by means of superheated steam 28 per cent. to 30 per cent. of paraffine and 2 per cent. to 34 per cent. of oil.

A NEW ROTARY PUMP.

From "Les Mondes."

This machine works very simply, and after the manner of certain canals in the animal economy, imitating the vermicular or peristaltic movements of the intestines in their spontaneous motion which aid digestion.

Revolving arms, turned by a crank, carry friction rollers, which, in rolling upon an elastic tube, press before them the liquid or gas that it contains, while the tube, regaining its form after the compression, exerts an aspiration proportioned to the elasticity of its sides.

The plan is admirably adapted to all the requirements of storing or transporting wines.

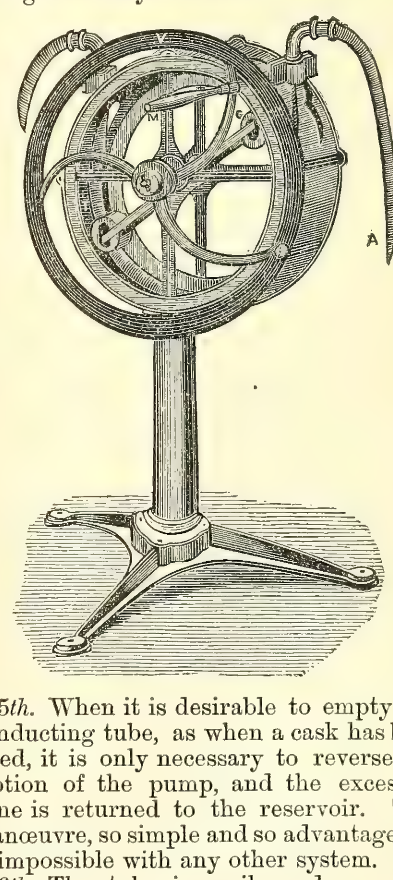
For this use it offers the following advantages:

1*st.* The wine traverses the pump without shock (batter); an important consideration, and belonging especially to this machine. While in ordinary pumps the wine sustains considerable beating and jolting, in this new apparatus it passes over as in a siphon, and flows without encountering any obstacle, in an open canal.

2*d.* The wine undergoes no alteration by its passage through the tube; long experience having proved that the rubber of which the tube is made cannot injure the most delicate wine.

3*d.* There is no contact of the liquid with any oxidizable metallic surface, nor with greasy coated surfaces, such as, unfortunately, occurs in all other present systems.

4*th.* This pump yields a greater useful effect, in proportion to the force applied, than any other pump, whether reciprocating or rotary.



5*th.* When it is desirable to empty the conducting tube, as when a cask has been filled, it is only necessary to reverse the motion of the pump, and the excess of wine is returned to the reservoir. This manœuvre, so simple and so advantageous, is impossible with any other system.

6*th.* The tube is easily and promptly filled.

7*th.* It serves to agitate the wine at the moment of sizing, by forcing through the siphon a powerful current of air.

8*th.* Finally, this new wine-pump requires no care to keep it in order ; it can be cleaned with facility, or repaired, if necessary, without having recourse to a special workman ; the replacing of the rubber tube, after very long use, being all that is necessary.

This pump was invented by MM. Mackintosh & Guibal, the celebrated rubber manufacturers. It has been extensively used by wine and beer manufacturers, who testify to its advantages. By using porcelain rings for ends and joinings, it may be used in pumping vinegar. If prepared rubber be substituted for the natural product, the pump will be very serviceable in raising petroleum and similar oils.

THE GREAT NORTHERN TELEGRAPH CABLE.

From "The Engineer."

Now that the understanding which is to supply, or, at any rate, to assist in, the establishment of the long needed telegraphic communication between the Chinese ports and the Continent of Europe, has so far advanced toward completion that the vessel with the first section of the cable has actually sailed, a few facts detailing the measures that have been taken for achieving the objects for which the Great Northern Telegraph Company has been established may not prove uninteresting. It is exactly six months since the Danish frigate Tordenskjold was despatched from Copenhagen, and cast anchor in the Thames as the pioneer vessel in the expedition. The Tordenskjold is said to be the finest frigate in the service of his Danish Majesty; but it may be remarked that in both appearance and size there are many among the old wooden vessels in the British navy not pretending to the title of "frigate" would completely surpass her. This will be readily understood when we mention that she is but 160 ft. in length and 42 ft. in beam amidships, with a capacity of 1,435 tons. In general appearance she is strikingly unlike what a closer inspection proves her to be, a screw-steamer, chiefly from the large size of her masts and the comparative diminutiveness of her funnel. In fact, under present conditions, that is with the greater part of her armament removed, this vessel might well be taken or mistaken for one of those Australian or East India clippers with which "Greens" and "Wigrams" have familiarized us of late years. However, frigate or otherwise, the Tordenskjold is evidently well adapted for the work she is now engaged upon, and if ever called upon to fulfil the duties for which she was originally designed, we have no doubt that she would not be found wanting. The other ships engaged in the work of laying the cable are the English screw-steamers Great Northern and Cella. These vessels both surpass the Tordenskjold in dimensions, the first named being in length 243 ft., in beam 32 ft.; and the second 300 ft. long, and 34 ft. in beam. The Great Northern, which is lying in the Thames, at Charlton, off the wharf of Messrs. Siemens Bros.—the firm who have been intrusted with the construction of the cable—is now being fitted with the tanks, drums, windlasses, and other apparatus necessary for the work she is to undertake. The scene on board at the present time is one of the most picturesque confusion ; on one part of the deck may be observed the instrument room, from whence it will be possible to detect the slightest fault in any portion of the cable during the process of submersion, and these instruments are being fitted up by an entirely different class of workmen to those who are to be seen close by placing in position, with the aid of screw-jacks and levers, accompanied by the expenditure of much "undefiled Saxon," the engine which is to aid in the process of transferring the cable from the factory to the vessel. After having glanced at the various objects on deck, the visitor's attention will be drawn to seven enormous chasms. These extend downwards from the main deck into the hold, and are the tanks in which the cable will be coiled during the outward voyage.

From the vessels that are to lay the cable the natural transition is to the cable itself. This, with the exception of the completed portion despatched on board

the Tordenskjold, is in course of manufacture by the firm to whom we have already referred, Messrs. Siemens Bros., of Westminster, and the Charlton Telegraph Works. It consists of three distinct divisions, known respectively as the main cable, the intermediate cable, the ordinary shore end and the heavy shore end. Of these the "core"—through which the actual transmission of the electric current is effected—is the same throughout, the distinction arising from the different methods adopted of "sheathing," or protecting this core according to the varying liability to exposure and injury. The core consists of a strand of seven copper wires, cased with tin, weighing 300 lbs. the nautical mile, covered with the composition known as "Hooper's Dielectric," which of itself weighs 200 lbs. the mile; this process being completed, the core is again covered with a layer of felt, coiled in tanks under water, and subjected to tests as to its electrical condition before being, what is termed, "sheathed." As we have before remarked, it is the sheathing that gives the distinctive names to the cables, and it will be best, with the view of insuring a clear idea of the processes, to describe the four sheathings separately. There is first the outer covering for the "heavy shore-end cable," consisting of a serving of jute next to the core, a sheathing of "best best" drawn and galvanized iron wires, 0.160 in. diameter, weighing per nautical mile about 5,023 lbs., a serving of jute round the sheathing, a second sheathing of "best best" rolled and galvanized iron wires, 0.380 in. diameter, and finally an outer protection of two layers of bitumen compound, with two layers of jute between, laid on as follows: The first coating of the compound next the wires, then a serving of yarn, then a second coating of compound, and lastly a close serving of tarred yarn, laid in an opposite direction to the one previously laid on. The outer covering for the "ordinary shore-end cable" consists of a serving of jute next to the core, a sheathing of "best best" rolled and galvanized iron wires, 0.300 in. in diameter, weighing per nautical mile about 13,311 lbs., and finally an outer protection of two layers of bitumen compound, with two layers of jute between, laid on as before specified. The outer covering for the "intermediate cable" is composed of a serving of jute next to the core, a sheathing of "best best" drawn and galvanized iron wires, 0.160 in. diameter, weighing per nautical mile about 5,023 lbs., and the outer protection of two layers of bitumen compound and jute. The outer diameter of this cable is about 1.06 in., and its weight per nautical mile about 3 tons 2 cwt. The outer covering for the "main cable" is a serving of jute, next the core, a sheathing of "best best" drawn and galvanized iron wires, 0.095 in. diameter, and the outer protection of bitumen compound and jute. The outer diameter of this cable is about 0.86 in., the weight per nautical mile being about 1 ton 16½ cwt. Messrs. Siemens Bros. are able to sheathe the cable at the rate of 180 to 200 nautical miles per week.

The manufacture of the first section of the cable—that to be laid between Hong Kong and Shanghai—is now complete; it consists of 685 nautical miles of main cable, 272 miles of intermediate, 111 miles of ordinary shore end, and 30 miles of heavy shore end—in all, 1,098 nautical miles. Of this the following has been shipped on board the Tordenskjold: 50 miles of main cable, 4 miles of intermediate, 32 miles of ordinary shore end, and 10 miles of heavy shore end—a total of 96 nautical miles. The Great Northern will receive on board, into seven iron tanks, the following lengths of cable: 140 miles of main cable, 58 miles of intermediate, 70 miles of ordinary shore end, and 20 miles of heavy shore end, or 288 nautical miles in all. The Cella will take in after the Great Northern, and will receive 495 miles of main cable, 210 miles of intermediate and 9 miles of ordinary shore end—a total of 714 nautical miles.

We may mention, in conclusion, that the second section of this company's line—namely, that from Shanghai to Posiet Bay—is also in course of manufacture at Messrs. Siemens' works. This consists of 990 miles of main cable, 92 miles of intermediate, 96 miles of ordinary shore end, and 20 miles of heavy shore end, thus comprising an entire length of 1,198 nautical miles. The sheathing of 150 miles of this cable is complete.

THE last girder of the Sutlej Bridge was hoisted on the 13th July, completing the communication between Lahore and Calcutta.

MANUFACTURE OF RUSSIA SHEET IRON.

From "The Bulletin of the American Iron and Steel Association."

Herbert Barry, Esq., late director of Estates and Ironworks of Vuicksa, thus describes the manufacture of sheet-iron in Russia :

"The refined iron is hammered under the tilt-hammer into narrow slabs, calculated to produce a sheet of finished iron two archimes by one (56 inches by 28 inches), weighing when finished from 6 to 12 lbs. These slabs are called *balvanky.* They are put in the reheating furnaces, heated to a red heat, and rolled down in three operations to something like a sheet, the rolls being screwed tighter as the surface gets thinner. This must be subsequently hammered to reduce its thickness and to receive the *glance.* A number of these sheets having been again heated to a red heat, have charcoal, pounded to as impalpable a powder as possible, shaken between them through the bottom of a linen bag. The pile then receiving covering and a bottom in shape of a sheet of thicker iron, is placed under a heavy hammer ; the bundle, grasped with tongs by two men, is pocked backward and forward by the gang, so that every part may be well hammered. So soon as the redness goes off, they are finished, so far as this part of the operation goes. So far they have received some of the *glance*, or necessary polish ; they are again heated, and treated differently in this respect, that instead of having the powdered charcoal strewed between them, each two red-hot sheets have a cold finished sheet put between them ; they are again hammered, and, after this process, are finished as far as thickness and glance goes.

"Thrown down separately to cool, they are taken to the shears, placed on a frame of the regulation size, and trimmed. Each sheet is then weighed, and after being thus assorted in weights, are finally sorted into first, second, and thirds, according to their *glance* and freedom from flaws and spots. A first class sheet must be like a mirror, without a spot upon it.

"One hundred poods of *balvanky* make 70 lbs. of finished sheets ; but this allowance for waste is far too large, and might easily be reduced. Four heats are required to finish.

"The general weight per sheet is from, 6 to 12 lbs. the larger demand being from 10 to 11 lbs. : but they are made weighing as much as 30 lbs. and may then almost be called thin boiler-plates, being used for stoves, etc. Besides the finished sheets, a quantity of what are called *red sheets* are made, which are not polished, and do not undergo the last operation.

"Taking the Michælofskoi Works, which are the largest sheet-iron ones in the empire, I found that the power running the sheet rolls was equivalent to 40 horses, the rolls making 70 to 80 revolutions a minute. The hammers used are powerful, having the surface of the stroke very large—just the contrary shape there to the ordinary tilt-hammer. A gang turns out in a shift from 450 to 500 sheets.

"In the central works, where they make sheet-iron from puddled iron, they *roll* it into the necessary size, and then roll this *balvanky* into half-ready sheets, with the same sort of rolls as are used in the North, but which however run much slower ; the finish being given also by hammers in the same manner, but leaving out the final part of the operation of placing cold finished sheets between the hot unfinished ones. The hammers are not so heavy, and the heating furnaces are not so well constructed and do not regulate the flame as well. The trimming, sorting, etc., is carried out in just the same way.

"The waste is really greater in the Central Works than it *should* be in the North, as the hammered iron does not leave such a raw edge as the puddled.

"A fact that proves the superior manufacture of the North over the north parts of the empire is, that whereas in the former sheet-iron is the best paying, in the latter it is the worst business.

"For the uses to which sheet-iron is put, ductibility is of the first consequence, and no sheet-iron is of passable quality that will not bend four times without breaking ; some made in the Oural I have bent as much as nine times without showing the break. Coupled with this quality, the glance must be taken into consideration, as good polished iron will not take so much paint as the inferior polished."

ON THE CHEMISTRY OF POTABLE WATERS.

By MR. RICHARD WEAVER, C. E.

From "The Builder."

It is not my intention to give an account of the functions performed by water as a physical agent; of the wonderful changes it has worked and is working upon the face of the globe; of its power as a transporting agent; nor, indeed, of the manifold purposes to which it is turned into usefulness by the ingenuity of human intellect. Yet, as a reservoir, as a store, as a source of power, I may just mention that we possess an immensity in our tidal rivers and around our coasts, which as yet is almost undreamed of in our philosophy; its magnitude is such that when viewed side by side with all the combined steam power of Britain, the latter appears insignificant and microscopic; and in the hands of a Wellington in science greater changes by far may be effected from this source than from the steam of Watt and of Stephenson. But I will lay before you some of the leading characteristics of water as employed for sanitary purposes, such as they occur to me; will point out their impurities, their source and mode of detection, examination, and possible estimation.

Passing over the modes in which chemists formerly examined water, I come to the

NITROGEN, CARBON, AND AMMONIA METHODS.

In the present day, I believe, there are only two methods of approximately determining the value of domestic water. The first is known as Frankland & Armstrong's gasometric system, and the second as Wanklyn, Chapman, & Miles Smith's ammonia system. Between each set of inventors there exists great rivalry, each insisting upon the accuracy of their system to the detriment of the other. Of this rivalry I will merely note my belief that, *theoretically*, Frankland's process is as perfect as any process is ever likely to approach; while, in practice, Wanklyn's ammonia method is much to be preferred. This being so, I shall give you a brief outline of the gasometric mode of Frankland, and then proceed to a more detailed and illustrated account of that of Wanklyn, premising that the results are such as I have myself personally obtained.

FRANKLAND AND ARMSTRONG'S GASOMETRIC PROCESS FOR THE ANALYSIS OF ORGANIC MATTER IN WATER.

These chemists endeavor to show, not the actual weight of organic matter present in a given bulk of water, but that of some of its constituents, and also some of the products of decomposed organic matter, which latter is termed by Frankland "the skeleton of sewage." First, the organic carbon and the organic nitrogen. These are converted into gas, and measured as carbonic acid and as nitric oxide. Second, the nitrates and nitrites; and, lastly, the ammonia. By this means the whole of the nitrogen contained in the water is valued, and a distinct estimate is made of the nitrogen rendered harmless by oxidation, and of that which yet exists as putrescible organic matter.

The first operation is to evaporate a known bulk of water to dryness with a prior addition of sulphurous acid, to expel all carbonic acid from carbonates, and also to destroy the nitrates and nitrites; the residue now contains the whole of the nitrogen of the organic matter and the nitrogen of the ammoniacal salts; and by making a separate estimation of the latter—through the Nessler test, to be hereafter described—and subtracting this from the total nitrogen obtained, we arrive at that corresponding to the organic nitrogen.

The process by which these determinations are made, somewhat resemble the combustions in organic analyses, but are much more complicated, and require greater delicacy of manipulation.

As an indication to the limits of this test, it is stated by Frankland that the $\frac{1}{65000}$ part of a grain of nitrogen and the $\frac{1}{1000000}$ part of a grain of carbon can with certainty be determined.

I shall not enlarge upon their mode of estimating the quantity of nitric acid; I have already indicated it is done as nitric oxide and the volume of gas measured off.

But I must draw your attention to a characteristic point in all the analyses of waters by Frankland, and notably indicated in the recent report of the Royal

Commission for Rivers Pollution, and in the examination of the metropolitan waters.

I refer to "the previous sewage contamination" column of such analyses. This question is a moot point with chemists, some considering it almost a worthless indication, and others insisting upon its great value in deciding the relative goodness or badness of potable water.

For my own part, I incline to think it as a somewhat vague term, and calculated to mislead the public, not as being worthless in its indications, but as really showing too little.

By the term "previous sewage contamination" would generally be implied the actual quantity of sewage with which a water was, or had been, contaminated at the period of its examination; but such is not the case, as I read Frankland's definition of the term, which, expressed in a few words, means the actual present amount of the *skeletons* of sewage,—of that which *was*, and has no reference to that which is at the present moment active and living sewage!

From which it follows that, probably, a water may contain variable quantities of sewage, and yet, according to the "sewage contamination" column of Frankland, no return would be made, and, by inference, that no sewage was present. That this is so, I may mention, a certain water was examined repeatedly by me, at intervals—which said water shall be nameless —and I always found indications of sewage matter; and, on turning for verification to Frankland's sewage contamination column, in his analysis of the same water, I found that *no* previous sewage was present. Now, this may be considered as either discouraging or encouraging, as viewed from opposite motives; and yet it is easily explained from the fact of my showing active and putrescent sewage, or analogous matter, whereas Frankland's column merely shows that which was ancient sewage, but is now no longer sewage. And for this, as one ground of objection, I must protest against the term, "previous sewage contamination," as being vague and delusive.

We now arrive at the method devised by Professors Wanklyn, Chapman, and Smith, for determining the organic matter in water by

THE AMMONIA SYSTEM.

Coupled with this, I shall introduce you, somewhat briefly, to a general system of water analysis, as suggested by these gentlemen, premising that much of it is obtained from older methods, now broken up and partly re-absorbed in modern systems. I divide the course into six divisions, as follows:—

1st. Hardness.
2nd. Chlorine.
3rd. Total residue and loss on ignition.
4th. Nitrates and nitrites.
5th. Ammonia.
6th. Organic matter.

HARDNESS.

The hardness of water has reference to its soap-destroying powers, and is caused by the oxides of calcium, magnesium, and iron, combining with the fatty acids of the soap forming insoluble salts; and so long as any of the earths remain in solution, the soap cannot exercise a detergent action; hence the value of soft water for cleansing purposes. This which I now hold before you is a solution of soap in aqueous spirits of wine, and is standardised by a somewhat tedious process to an equivalent of 16 grains of calcic carbonate per gallon of water; or, in other words, corresponds to 16 degrees of hardness, and with 1,000 grains of water of such hardness, 32 test measures, or 320 grains of soap solution, will just neutralize, and cause a lather to form, on thoroughly agitating, and will last about five minutes.

Upon such a water I now operate, and note the result.

CHLORINE.

The reason for determining chlorine in a potable water is that it points to a possible origin in sewage, for no sewage can exist in water without chlorides being present, sewage being rich in chlorine, especially from the urine. Yet, on the other hand, chlorine may very probably be present without any sewage, and it becomes a problem whether its source is due to sewage or to the geological character of the strata through which the water may have flowed.

The determination of the quantity of chlorine is very simple, and yet wonderfully accurate.

We first prepare a solution of argentic nitrate in pure distilled water, and to a

known strength. To the water under examination we add a few drops of neutral potassic chromate, and then the silver nitrate,—as in the experiment now before you—until a faint tinge of reddish colored silver chromate denotes the end of the chlorine reaction ; and from the amount of silver solution employed we estimate the chlorine.

TOTAL SOLID RESIDUE, ETC.

For this experiment it is essential that the quantity of water employed shall be very accurately measured, and that a delicate balance is at command, because each millegram—about $\frac{1}{65}$ part of a grain—of residue is equivalent to 1 grain per gallon of water.

The apparatus which is usually employed for the purpose of estimating the total solid matter contained in a water consists of a small copper or tinned vessel for generating steam. Through the mouth of the vessel passes a perforated cork, and again a large glass funnel ; into this latter is arranged an accurately weighed platinum dish. We now take 70 cubic centimeters of the water under examination, and place it in the platinum dish ; steam being generated in the lower apparatus, rises through the funnel, and, acting upon the platinum dish, the water contained therein is quickly evaporated—in fact, in practice, I find that about forty-five minutes are amply sufficient time for the purpose. The dish and its contents being now well dried and weighed, the excess of weight over the first weighing represents the amount of solid residue. If it is further desirable to ascertain the amount of loss on ignition, we carefully burn off all carbonaceous matter, at a faint red heat. Moisten with ammonia carbonate, well dry, re-weigh, and the difference represents the volatile matter. This process, as previously stated, is of very little value in estimating the character of water.

NITRATES AND NITRITES.

These are the skeletons of Frankland's sewage, and the mode by which their quantity is determined is exceedingly elegant.

We take a retort, and introduce 100 c. c. of water, to this add 60 c. c. of caustic soda solution free from nitrates, etc. The contents are now distilled until about 100 c. c. remain within the retort, and until the Nessler test is incapable of showing ammonia. Into the retort on cooling is added a small piece of the metal aluminium ; it is closed with a cork, through which passes a small tube in the manner I now show you ; it is filled with pieces of broken up tobacco-pipe, or analogous matter, and moistened with dilute chlorhydric acid. On standing for a few hours, the action is complete ; the whole of the nitrates have been resolved into ammonia, and the ammonia being distilled off, its quantity is determined by the Nessler test.

The process is so exceedingly delicate that it may be termed microscopic ; indeed, a very small fraction of a grain of nitrates per gallon being readily ascertained. As to the relative value of the nitrates in a water in determining its quality, there is much difference in opinion, some chemists allowing that considerable quantities may be permitted without detriment, whereas Frankland would probably condemn a water if even a gallon contained but half a grain of nitrates !

AMMONIA.

The estimation of ammonia in water may fairly be considered to belong to the domain of microscopic chemistry when the Nessler test is employed.

I will first describe this test. We dissolve 50 grammes of potassic iodide in a little hot distilled water, placing the dish in a water-bath, and adding a strong solution of bichloride of mercury. We continue the mercury solution until a point is reached at which the red precipitate formed no longer dissolves on agitation. We then filter, and to the filtrate add 150 grammes of solid caustic soda in aqueous solution, and then dilute the whole to the volume of 1 litre. A further addition of about 5 c. c. of mercuric chloride imparts sensitiveness. Allowing all sediment to settle, and pouring off the clear fluid, we have the Nessler reagent such as I now show to you.

If we take a water containing a trace of ammonia, and add the test, we obtain a yellowish brown coloration ; and according to the intensity of this color we calculate the amount of ammonia present.

We have now arrived at a stage in water analysis when we determine the presence of matters that are of prime importance in judging of quality ; that is, the

ammonia and the urea, and it is astonishing the minute difference in quantity which marks the point between waters that are foul and stinking, and waters that are good and wholesome.

THE ALBUMINOUS SUBSTANCES.

The most important of all the substances to be sought for in water intended for domestic purposes, is undoubtedly the nitrogenous organic or albuminous matter, and it is primarily by this test we judge of the antecedents of water, and the character and source of its contamination. It is simple and elegant.

To the remnants of the last experiment we add a strongly alkaline solution of potassic permanganate, and distil off not less than 200 c. c., and until Nessler ceases to show the presence of ammonia; for you must understand that the action of the permanganate is to cause most of the nitrogen from the organic nitrogenous matter—not nitrates—to be evolved as ammonia, and by estimating the quantity of this we have a fair idea of the quantity of organic matter on multiplying the result by ten.

The delicacy of these tests is truly wonderful, for we can directly estimate ammonia in water when its weight does not exceed the $\frac{1}{100000000}$ part of the water in which it is dissolved; and when we concentrate by evaporation or distillation, we increase its delicacy *at least* tenfold. We have now arrived at the end of our chemical examination of potable waters, and I will just add a few words as to the characteristics of really good water.

It should be clear, colorless, and transparent when viewed through a considerable stratum; it should be perfectly free from smell, both at the ordinary temperature and when heated to about 90 deg. Fahr. It is well also if a little lime or baryta water be added previously to warming; its hardness must not be excessive, and, above all other considerations, it must be free from sewage matter. This is of vital importance, for we have it on record for years past, and, in fact, there is not a summer or an autumn comes without hundreds of human beings that are carried away to an early grave from the use of water polluted with sewage; and excepting in the very vilest of waters, its presence cannot be detected excepting by competent chemical examination, for it is an ascertained fact that waters which are clear and fair to look upon, that are beautiful and sparkling to the eye, may, nevertheless, be veritable poison-cups.

Before closing, something will possibly be expected upon the second phase of water—that is, sewage. Much has been said and written upon this subject of late years; but very little has been accomplished towards solving the problem of what shall we do with our towns' sewage, as you are aware there are at this present moment three systems in vogue, viz:—

Deodorization with disinfection, of which the ferric chloride process is a type.

Secondly, the precipitation process, by which a portion of the mechanically-suspended matter in sewage is thrown down, of which the lime, the alum, the clay, and Sillar's processes may be given as types. In this class are attempted to be accomplished the objects of the first, and also to derive a profitable manure; and I scarcely need remind you that they generally fail in the first object, and some of them in the second.

Thirdly, deodorization disinfection, and a profit is endeavored to be attained by the irrigation of land with sewage. This is a very ancient mode; indeed, it appears to be coeval with man. Like every thing else, chemists and others differ as to whether this system of treatment is really efficient, some contending that the effluent water flowing from off the land, after its functions are here ended, is not in a much better condition than when it was turned on. Now, this objection seems to me, after some years' consideration of the subject, observation in various parts of the world, and a trifle of experiment, to be a very futile objection; for it is evident, upon reflection, that a sufficiency of filtration through, and not over, porous soil has not been attained; for, I take it, the absorbent power of soil will not be called in question, or what is the use of manure?—it must needs be washed away by the first smart shower. There are others—for example, the Rivers Pollution Commissioners—who contend, and I go with them a long way, that the water, as a rule, flows away remarkably pure, deprived of 90 per cent. of its impurities—the amount I give from memory—and this, you will understand, is in practice; but I go further, and contend that 99 per cent. should be removed, being, however,

fully aware that greater filtration is requisite,—not ordinary filtration, but that through land, nature's grand disinfectant.

There is, however, another objection to irrigation, viz., that a nuisance and probable danger are created by putting sewage upon land in the first instance; that is, the sewage being in an active stage of decomposition on arriving at the place of absorption by the soil, the gases of decomposition are diffused through the air at all points between the places of absorption and first contact with the open air. This I conceive to be a feasible objection, within certain limits, upon these grounds:—It is a condition of all matter to undergo decay and change through decomposition; it is thus with sewage, especially animal sewage,—a medium between that which was and that which will become life. Under certain conditions, especially of temperature, this decomposition is actively promoted; and I concede that from some causes—either of distance or of time—a sufficiency of decomposition may have been attained to create a nuisance and a danger at the points of distribution of the sewage in question. Now, this is a condition I have long foreseen may probably arise, and have from some attention and a little experiment endeavored to contribute my mite towards the knowledge tending to a solution of the problem.

I need not give you any details of all the schemes that entered my mind and were developed by experiment; suffice it that that which I found the most successful was chlorine, another was oxygen, but I will now only trouble you with the former. This from limited experiment I find to answer the required purpose; it acts instantly upon the organic matter of sewage; upon that in a putrescent state, the gases are fixed or decomposed, ammoniacal salts are secured in the water, deodorization and disinfection are so effected that after a lapse of even weeks not a trace of unpleasant odor is perceived, and when this sewage is freed from suspended matter you cannot from mere external evidence tell it from the finest potable water.

The process I propose is something after this manner: chlorine to be generated by the perpetual regeneration scheme of Walter Weldon, in which chlorine is obtained from chlorhydric acid through the agency of manganic oxide, the same oxide being used over and over again for hundreds of times; so that the expense is reduced to that of the chlorhydric acid, the labor, and wear and tear of plant; and you are aware this acid is cheap enough, being a waste product of the alkali works, and can be purchased in a concentrated state at 40s. or 50s. per ton,—a sufficiency, I believe, to treat millions of gallons of sewage.

I shall now conclude this exhaustive lecture,—that is, exhaustive of your patience and good nature—not the subjects, for of these it is a mere outline—and give you some idea of the value of sewage, from a calculation I made recently, based upon an average of fifty samples of Leicester sewage. The value of the ammonia alone in a year's flow, if placed upon the market and sold at current rates, would realize very nearly £40,000; and this substance, although by far the most valuable constituent, is not the only one, for we have the phosphates and the alkalies, and others; and you will agree with me that there could be no honor too great for the State to confer upon that man who shall effectually solve this problem of utilization of waste, although I do not believe it will ever fall to the lot of any individual to achieve undivided success, but will rather burst forth spontaneously from many minds, and will attain success, as have all the great events of modern days,—like our railways, our steamers, and our electricity.

Russian papers lately received publish the text of a convention which has just been concluded between the Russian and Austrian Governments for the union of the Kieff-Odessa Railway with that of Leopol-Vienna *via* Volotchisk and Tarnopol. It is provided that the gauge shall be different, as in the case of the Russo-Prussian lines, so that the Austrian carriages will not be able to pass into Russia, nor Russian into Austria.

The preliminary arrangements for the construction of the International Bridge at Buffalo are now being carried out, and it is understood that proposals will shortly be made for raising the necessary capital, $1,000,000, by bonds to be issued in England.

ON THE ESTIMATION OF MANGANESE IN SPIEGELEISEN AND FERRO-MANGANESE.

By THOMAS ROWAN, F. C. S.

From "Engineering."

The following process for the determination of manganese is, I need hardly say, not novel; but having had occasion to make many estimations of manganese in spiegeleisen and ferro-manganese, I can recommend it as superior for speed and accuracy, where manganese in quantity has to be determined, to the other processes commonly resorted to.

A convenient quantity of the sample, say 20 grains, in as fine a state of division as possible, is digested in a long-necked flask with about $1\frac{1}{2}$ oz. of hydrochloric acid until complete solution is effected. The solution is then oxidized with chlorate of potash ($K\,O$, $C\,O_5$, or $K\,C\,O_3$) added from time to time, and finally boiled until traces of chlorine can no longer be detected.

The solution is now saturated by liquid carbonate of soda ($Na\,O$, $C\,O_2$, or Na_2, CO_3) added in small successive quantities, the flask being well agitated after each addition of the alkali. On nearing the point of saturation each addition of the carbonate of soda occasions the separation of small quantities of carbonate of iron and manganese, which disappear on the flask being shaken. When this is observed the alkali must be added with extreme caution, but the deep blood-red color now acquired by the solution will, after a little practice, be a sufficient indication to the operator that the desired point of saturation or neutralization has been attained. Or, if it is preferred, the smallest excess of carbonate of soda may be added, and the permanent precipitate which forms, re-dissolved by the cautious addition of hydrochloric acid introduced drop by drop.

Before treating with carbonate of soda, the solution should be evaporated to as small a bulk as possible, the presence of much free acid causing the expenditure of an unnecessary amount of alkali, and the violent effervescence caused by the escaping carbonic acid, often entails loss by the projections of portions of the solution from the flask.

From 6 to 8 oz. of water are now added and the iron precipitated as the basic acetate of iron by the addition of a concentrated solution of acetate of soda (NaO, $C_4\,H_3\,O_3$, or Na, $C_3\,H_2\,O_2$). If the solution has previously been successfully neutralized with carbonate of soda, the ferric acetate will at once make its appearance, but if that point has not been reached the iron will only precipitate after boiling, and then not completely, and the precipitate will be found to be so gelatinous as to cause much trouble by clogging the filter.

After the addition of the acetate of soda, the flask and contents are briskly boiled for about twenty minutes, and then allowed to repose for a few minutes, that the acetate of iron may settle to the bottom of the flask, when the solution is carefully decanted from it on a filter. More water is then added to the flask with a few drops of acetate of soda, boiled for 5 or 6 minutes and again decanted from the precipitate. This is repeated a third time. The acetate of iron can then be thrown on the filter and washed with boiling water. The filtrate, with washings, is removed to a beaker and brought to a temperature of about 100 deg. Fahr., and a stream of chlorine gas passed through until a faint smell of that gas can be detected from the liquid. This is ascertained by stopping from time to time the passage of the chlorine, blowing from the surface of the liquid in the beaker the gas that may have lodged there and then testing the smell. If chlorine can be detected the addition of the gas is finally discontinued. The beaker is now carefully covered and set aside in a moderately warm place for six hours. The precipitated binoxide of manganese ($Mn\,O_2$ or $Mn_2\,O_2$) is removed by filtration, and chlorine is again passed through the filtrate to ascertain whether all the manganese has been removed. When the precipitated manganese settles to the bottom of the beaker, if the liquid above is purple-colored it indicates that an excess of chlorine has been used, and that permanganic acid has been formed. This is easily remedied, as the permanganic acid is at once reduced to the binoxide by the presence of any organic matter. A few

drops of alcohol may be added, and the precipitated binoxide of manganese filtered off.

The precipitated binoxide of manganese is redissolved by pouring hot dilute hydrochloric acid on the filter. The manganese is reprecipitated as carbonate by a solution of carbonate of soda, and boiled well to expel all carbonic acid, the carbonate of manganese being slightly soluble in carbonic acid. The carbonate of manganese is then collected on a filter, washed well with boiling water, dried, ignited, and weighed as the red oxide Mn_3O_4.

The binoxide of manganese has such a tendency to appropriate alkali that it cannot be directly ignited to the red oxide. When this is done without redissolving and reprecipitating as carbonate, I have found that one part of the ignited precipitate contains 0.0842 of alkali, which must be deducted from the weight before calculating the percentage of metallic manganese.

If the weight of the ignited red oxide thus obtained be 3 gr., the following calculation is made :

Wt. of red oxide ppt.

1 : 0.0842 :: 3 : 2.7474.

In a rigorous analysis, however, it will be found more satisfactory to proceed as directed above, viz.: redissolve the binoxide of manganese first obtained, and reprecipitate as carbonate before proceeding to ignite, and weigh. The amount of metallic manganese is readily ascertained from the weight of the ignited red oxide, 100 parts of which contain 72.05 parts of metallic manganese.

ON THE RELATIVE SAFETY OF DIFFERENT MODES OF WORKING COAL.

From "The Mining Journal."

It was maintained by the author that whilst there was no possibility of freeing the workmen engaged in coal mining from accident, there was reason to hope for a considerable diminution in the proportion of those killed to the number employed. It was the purport of this communication to show that the mode of getting coal had considerable effect on the safety of the workmen. The accidents incidental to mining were classified by Her Majesty's Inspectors of Coal Mines under five heads, as arising from explosions, from falls of roof or of coal, in shafts, from miscellaneous causes underground, and on the surface. It appeared that in the years 1866, 1867, and 1868, out of a total of 3,686 casualties, 1,091 were the result of explosions, and 1,255 of falls, or, respectively, 29 per cent. and 34 per cent. of the whole ; the remaining 37 per cent. being attributable to other causes, which were not influenced by the mode of working. The different methods of getting coal, which were described in detail, were the practical application of two distinct principles. One idea was, to remove the coal at two operations, and this was practised in the bord and pillar work of the North of England, in the bank work of Yorkshire, and in the stall work of South Wales. The other idea was, to remove the whole of the mineral at one operation, as exemplified in the long wall system of the Midland Counties. In the latter case, as the faces advanced, packwalls of roof rock, or bind, were built at regular intervals, and, whenever a sufficient width of opening was obtained, the roof settled down, with or without fracture, upon these packs. Accidents by falls might fairly be brought to the test of figures, for, although the roofs of various seams might differ much, the averages of large districts were likely to be uniform. Of a gross tonnage of 198,636,043 tons obtained by pillar work in 1866, 1867, and 1868, the casualties by falls were 814, or 231,739 tons of coal for each life. Of a gross tonnage of 22,899,000 tons extracted by the long wall plan the casualties were 75, or one life for every 305,320 tons. If the latter ratio existed in pillar work the casualties would have been reduced from 814 to 614, or a saving of 200 lives. In these calculations certain coal fields, which yielded about three-tenths of the produce of the whole kingdom, had been excluded ; as in North Staffordshire, Cheshire, and Shropshire both modes of working coal were adopted, and the same was the case in Scotland. The mortality from falls was greatest in

South Staffordshire, where the lofty cavernous openings killed off one man for every 214,517 tons of coal raised, or an excess over the ratio of 35 per annum. There, too, the coal was obtained by both methods, but the greatest number of accidents took place in the Thick seam, which was worked in pillars. The greater safety of long wall mines from falls was owing to the narrow width of the working places, to the constant change to a new roof, so that there was not time for atmospheric action, which greatly weakened the roofs of many mines, and to the small extent of open mines, which permitted a more thorough examination. It might be thought that in long wall work the constant settlement, or bending down, of the roof would be attended with danger, but practically that was not the case. If a fracture occurred, it was not by the running down of a number of loose fragments, but a general settlement took place gradually, accompanied with so much noise that warning was given, when the workmen retired. The excessive mortality of some pillar districts was owing to the weak, under-sized pillars, which were crushed and sank into the floor, and induced a weak, jointy state of the roof. The goodness of a roof as often depended upon the way in which it was managed as upon the character of the material of which it was composed.

With respect to explosions, the author contended that the mode of getting coal had more influence on this question than was usually allowed; and whilst fans, safety-lamps, the absence of gunpowder, and all sorts of precautionary expedients were proposed, and were more or less adopted, the effect of the mode of working, perhaps the most important of all, had been lost sight of. It might be safely laid down that that mode of working was the safest from explosions which admitted of the most perfect ventilation, which was the least subject to a local failure of ventilation, in which the discharge of gas was best regulated, in which large accumulations of gas were prevented, and in which the superintendence of the workmen could be most thorough. In an unbroken coal field the free hydrogen might be assumed to be distributed evenly over small areas, and each ton of coal would have a certain proportion diffused through it. If this were liberated only in the coal actually cut, and when it was cut, the amount of ventilation could be exactly regulated to the production of the mine; and the mode of work, so long as ventilation was possible at all, would be immaterial. The fire-damp lying in coal seams possessed considerable mobility amongst the particles of coal, and, as it was often at a pressure in excess of the atmosphere, it travelled through the coal for some distance towards a point of discharge. The rapidity with which a given area was so drained, no doubt, varied in some proportion to the difference between the initial pressure of the gas and that of the atmosphere, and the amount of resistance which the gas met in permeating the coal. It also varied according as the openings were bordways or endways of the seam. In all probability it was three or four times the greatest on the end of the coal, as the cleavage planes were, to a certain extent, channels for the passage of the gas. Thus, in a headway on the end of the coal, the discharge of gas was most abundant at the back of the heading; while in bordways it was most perceptible at the sides of the heading, and in such a heading a large part of the gas would probably be let off for some yards on each side. When the excess of pressure was relieved the discharge might be supposed to vary with the changes in the barometrical pressure. It was suggested that experiments should be made in different localities, to ascertain (1) the quantity of gas given off per sq. yard of freshly cut surface, (2) to what extent this varied on the face or end, (3) in what ratio this discharge diminished with time of exposure, (4) to what extent barometrical changes affected the discharge of gas, and (5) by what amount the pressure of gas increased, as measured from the exposed surface inwards to the solid seam. It was believed such experiments would show that from 50 per cent. to 75 per cent. of the gas contained in the coal lying 10, 20, and 30 yards on each side of a bordways heading was liberated when, and after, this was driven.

As the free hydrogen gas came not only from the hewn coal, but also from the solid seam, it was important that the surface exposed to the air should be as small as possible. It was argued that every mode of pillar work liberated 3, 5, or 10 times the amount of gas per ton hewn in

the solid than was liberated by a system of long wall work. If, therefore, the diluting power of the air-current was the same in both cases, 3, 5, or 10 times more would be necessary in pillar mines than in long wall mines. In a mine under the author's charge this excessive discharge of gas in pillar roads was very noticeable. Long after a headway was driven the gas oozed out of the sides of the headway, and might be heard at a considerable distance. In the long wall faces this was not perceptible, as the gas given off there was that due merely to the coal hewn.

Again, in pillar mines from 6 to 20 times as much surface of coal was exposed as in long wall mines, and, therefore, such mines were from 6 to 20 times more subject to the effect of changes in the atmospherical pressure.

On inspecting the maps of mines worked by different pillar methods, and comparing them with the diagram showing a like extraction of coal by long wall, it was clear how large a proportion the gas discharged in the former must bear to that in the latter. It was frequently argued that this gas drainage was desirable, but it was submitted that before such a course could be with propriety recommended it was necessary to show that the ventilating current would be proportional to the discharge.

The ease with which a mine could be ventilated, and the freedom from local derangement, would depend much upon the cubic contents of open mine, upon the freedom from stoppings, doors, etc., and upon the general simplicity of the arrangements. For a like extraction of coal the cubic contents of pillar mines were from 10 to 20 times the amount of properly designed long wall mines, and the drawings showed clearly the relative simplicity of each. In every pillar mine the workings were driven in advance of the ventilating channels, and constant brattices were essential. It would be seen, by examining the reports, how numerous were the accidents from defective brattices.

In South Wales the working places were driven into the solid coal, and when finished had no channel left for a steady through current, and thus the chance of their harboring fire-damp was very great. In the north of England there were none of these dumb points, but the cubic contents of bords, in which there was no sensible current, was often very large. Whatever might be the difference of opinion with regard to barometrical changes in mines, it was reasonable to suppose that they would exert the least influence where the surface of coal which might exude gas was the least. The proportion which the surface exposed in pillar mines bore to that in long wall mines was from 10-20 to 1. The goaf of a long wall mine became approximately solid as the coal was extracted over large areas, and thus permitted of a general settlement. In pillar mines the tendency was towards the formation of many small goaves, where there could be no surface settlement. These goaves thus became so many gas holders. The long wall mode of work also admitted of the nearest approximation to goaf ventilation. The only open parts were the edges, and as these were cut through with roads a constant current could be maintained along them. It was possible, in a properly laid out long mine wall, to keep the goaf clear of gas as far back as it was open. In pillar workings there was no possibility of sending air into the goaf, and it thus became charged with gas. It was, therefore, submitted that the safety of mining operations might be increased by the extension of long wall working. It was satisfactory to be able to add that on economical grounds it was daily gaining in favor, and that simplicity, compactness, small cubic contents of open mine, small exposure of coal surface, regular gas discharge, and thorough ventilation, could be best attained in long wall mines.

England has 500 blast furnaces, which every year reduce 12,000,000 tons of ore to 4,800,000 tons of metal, and which consume 14,000,000 tons of coal. The manufactured metal is worth about $60,000,000.

The bridge over the Dee, forming part of the viaduct which supports the Chester and Holyhead line, is about to be entirely re-constructed.

The railway bridge lately erected over the Dnieper, near Kiew, is the largest work of the kind in Europe, being 3,503 ft. in length.

AN ARCHITECT'S ACCOUNT OF THE GIANT'S CAUSEWAY.

From "The Builder."

The curious and wonderful assemblage of basaltic pillars on the coast of the county of Antrim, Ireland, known as the "Giant's Causeway," has been a thousand times described by artist, essayist, journalist, traveller, and poet. It has been a meet subject for the whole artistic and literary phalanx of Europe and America. Topographers have rounded it, geologists hammered it, painters limned it, poets apostrophized it, and Vandal excursionists bid fair, if not stopped for the next generation, to trample it down to the sea level, or pick it to pieces, to satisfy an uncontrollable and unwholesome passion for carrying home "a bit of the Giant's Causeway," to ornament their chimney-boards. Amongst all the sight-seers who visited the Causeway, we have never known but one architect who visited it that described it. As this architect's account has not met the eyes of many, and as it is to our thinking one of the most interesting descriptions that have been given, we will present it to the readers of the "Builder." Though written many years ago, it has lost nothing of its interest. The writer was an architect of eminence in the sister kingdom, who held during his lifetime a conspicuous place in his profession, and lived to find a successful rival in the person of his own son. R. Morrison, architect, for he was the writer, enjoyed good practice in Ireland. One of the name in the sister island has impressed his character, as our readers know, upon his works.

Our architect thus describes the Giant's Causeway :—"The sea cliffs contiguous to the Causeway are particularly high. You approach it by a narrow path, or a long dreary precipice almost impassable. Every image which presents itself has something uncommonly grand and magnificent. Above you, the impending rocks to a timorous fancy threaten instant ruin; around you the sea presents immensity, unless where the shore of Scotland gives the idea of a world set at a proper distance for contemplation ; and below you the dreadful precipice produces an effect of inexpressible solemnity.

"The Causeway is a low head, extending from the head of the cliffs into the sea like a mole, consisting of a great number of polygonal cylinders or pillars, so closely united that the edge of a knife cannot be inserted between their adjacent sides. At the first view this head did not appear to me so grand as I expected from the drawings I had seen of it ; but when I came to walk on it, and to consider its plan and situation more attentively, it appeared a stupendous production of nature, extending from the bottom of the cliffs into the sea, but to what distance has never been ascertained. At low water the length of it appears to be 600 ft. ; its breadth in one place, 240 ft., in the narrowest, 120 ft. ; it is very unequal likewise in its height. In some places it is 36 ft. high from the level of the strand, and only 15 ft. in other places. The pillars of which the Causeway is formed stand most of them perpendicular to the plane of the horizon, yet the contexture of them is so adapted that there is no vacuity between them. I could not discern whether they run underground like a quarry or not. Some of them are very long, others short, and some for a large space are broken off at an unequal height, so that their tops make an even plane surface. Many of them are imperfect, crooked and irregular; others entire, uniform, and handsome, and these of different shapes and sizes.

"I found them almost pentagonal or hexagonal, a few excepted, of seven sides, and many more pentagons than hexagons; but they were all irregular, for none that I could observe had their sides of equal breadth. These pillars are some of them 15 in. and some 18 in., and some of them 2 ft. diameter. None of them are one entire stone, but every pillar consists of several joints or pieces, as I may call them, and the whole are jointed as close as it is possible for one stone to lie upon another, not jointing with plain flat surfaces. The upper ends of most of the pieces are concave, the lower ends convex, the prominences of which are nearly quarters of spheres, with rims round them. The length of each of these pieces which compose the pillars is 6 in., some 12 in., 18 in., and 2 ft., and easily separated, though so united in all appearance. When I parted them asunder, both the concave

and convex superficies appeared very smooth, as are also the sides of the pillars which touch one another, being of a whitish freestone color, but of a much finer and closer grit. When I broke some pieces of them, the inside appeared like blackish iron gray, somewhat like the best limestone marble before it is polished, but of an extraordinary hard, close and compact texture—their grit or grain so very even and fine that it hardly appears; but, where the stone is nearly broken, there it shows itself on its surface like a very minute, small glistening sand, thickly interspersed with the rest of the solid, and this (by reason of its parts being so closely combined together) has more specific gravity than most other kinds of stone. I must observe that, in my opinion, the curiosity of this place is much increased by the stones of which the pillars are composed being the irregular rather than the regular figures of geometry, as it is much more difficult to suit the sides of polygons together than squares and triangles, the latter being done easily by putting together two triangles equal to the square. I perceive in some of the stones the scheme of the 11th, 12th, 13th, 14th, and 15th propositions of the Fourth Book of Euclid, wherein an ordinate pentagon was inscribed; about it was circumscribed a circle; in another I observed a cylinder circumscribed about a cone. There is nothing more surprising than the piles of rocks here composed of a vast number of polygons; the external angles of each exactly suiting that made by the adjacent figures, and some rising like a flight of stairs to a considerable height.

"At a small distance from the Causeway you discover in the impending cliff to the south-east, one large pile of those polygonal figures, so situated and united as to appear really to be what it is commonly called the Giant's Loom or Organ, as in perspective it resembles either. Another on the summit of the precipice has so much the resemblance of the chimneys of a house that the Laia, some ship of the Invincible Armada, mistaking it for a town, in the approach to it split on the rocks.

"From observing at low water, the rocks stretching a great length into the sea, and that there are similar ones on the opposite coast of Scotland, some have been led absurdly to imagine that there was formerly a design of uniting the kingdom by means of this Causeway!—a notion pregnant with folly. Others, from observing rocks in the precipice or cliff similar to those of the Causeway, have imagined that the sea, by undermining, has brought down these; but there is really no foundation for the remark, there not being any great similarity between the stone in the Causeway and the precipice; and the pavement of the Causeway extends along the shore, where it could not have fallen from the precipice; nor can we, with any degree of reason, attribute to a chance fall a phenomenon so regular, so perfectly connected, and so extensive. Others, again, with a superior display of penetration, endeavor to account for the figures of the stone from the crystallization of salts. This they found, I suppose, on the doctrine of l'Abbé Nollet, who, in his lectures on experimental philosophy, says that 'every salt when crystallized generally affects a figure which is proper to itself, and which probably depends on the figures belonging to its smallest part. Sea salt, for example, forms amber, saltpetre needles, sugar globules,' etc.

"For my own part, I think it most reasonable to imagine that nature, which pursues infinite diversity of plans, forming some things for the use, others for the pleasure, of mankind, has left this and such like curiosities as perpetual subjects for our admiration, that, from observing the wonders of the visible creation, we might be led to the sublime contemplation of the invisible Creator, and, as Democritus philosophized amongst the rocks of Abdera, were a man of reflection to confine his whole observation to this Causeway, and attentively to consider it, he would find himself surrounded by pregnant proofs of the divine wisdom and power. Indeed, all the works of human art must cease to attract if compared with this. Not the army of Xerxes, with an Archimedes to direct them, could form anything so wonderfully great, so uniformly various.

"The usual attempts to explain this phenomenon appear to me very absurd. It had its name from the ignorant credulity of the unlettered, and superstitious vulgar causes, often of more absurd errors."

So ends the description given by an architect of a visit to the Giant's Causeway.

NAVAL ORDNANCE.

From "The Engineer."

Our heavy ordnance is not what it ought to be. If it were we should not hear so many stories of the breaking up of shot and the premature bursting of shell. But why is it not what it ought to be? Where does the defect lie? In the rifling, undoubtedly; not in the gun. Our readers will remember that the result, if not the logical consequences, of the celebrated 7 in. gun competition, was the introduction into the service of the French rifling and a studded projectile. The principle of the Fraser gun is, of course, as we have always maintained, excellent. We complain now, as we have done before, that our heavy guns are not perfectly satisfactory, because the chief feature of the rifling at present in use is a gaining twist, and the chief feature of the projectile a number of holes in its sides. We do not hesitate to say that these are two radical defects, either of which would suffice to vitiate the system; the combination of the two leaves no room for surprise at the disasters which have already occurred, or at any which may occur in future. The rifling is that which throws the greatest strain on the projectile, and is least able to bear a strain itself; the projectile is that which is least capable of enduring any jar, and is best calculated to inflict a series of jars upon itself and upon the rifling. Never before was infirmity so well or so ill mated with infirmity. If, however, we were asked to pronounce which of the two evils, considered separately, is the greater, we should certainly decide for the projectile. Hardened at its point by a chill, and weakened in its sides by huge stud-holes, it seems to be always in antagonism to the objects of its own existence. We can see that every resource has been exhausted in the attempt to strengthen the metal, and we have not a word to say against any efforts in that direction. But the harder the metal is made the less ought its powers of coherence to be diminished afterwards. When we buy a sheet of postage-stamps we thoroughly understand the perforations to be made in order that each stamp may be easily detached from its neighbor; and all analogy would lead us to infer that when we find a similar arrangement elsewhere, it is made for a similar purpose. A glance at the projectile, bored for the insertion of the studs, or after the studs have been displaced by firing, at once suggests the idea of the perforated sheet of stamps. The fragments into which the shells are frequently broken carry out the simile only too well. It was a most unfortunate circumstance, as we pointed out at the time, that the committe appointed to decide upon the merits of the 7 in. guns was composed almost exclusively of military men. There were two elements almost entirely wanting—the practical knowledge of the sailor, and the skill of the mechanical engineer. The latter is required for a just decision upon all gunnery questions, and no one, however great his experience as an artilleryman, can know what are the exigencies of naval warfare, or what is required in a gun for naval service, unless he has had the training of a naval officer. It is for this reason that the Woolwich gun and the Woolwich projectile have exhibited their defects most conspicuously in those qualities which are most required at sea. Thus the weakness of the studded shell does not proclaim itself so manifestly when the projectile strikes the target directly as when it strikes obliquely. When fired at a Shoeburyness target, the line being almost direct, the shell generally penetrates tolerably well. But when the armor plate is set up at an inclination or angle to the line of fire, the shell no longer has the power invariably to force its way through, but often breaks into two or more pieces at the moment of contact, if it has not been previously broken in the gun. This is not the fault of the gun, nor of the shape of the projectiles, but simply of the system of rifling, which weakens the metal, while failing to insure a perfectly true axial rotation of the shot or shell. At sea it very rarely happens that the target—the side of an armor-plated ship—can be struck directly, so that the shell, if effective at all, is effective only under conditions which could not be secured in actual naval warfare. The combination of the gaining twist with the studded projectile introduces so many elements of weakness that

the spiral cannot be made sharp enough to give the shell sufficient rotation. The projectile, consequently, even when it does not break, enters the target with an uncertain, unsteady motion, which renders it very deficient in penetrating power, and this is especially the case with the heaviest guns. As a remedy for this evil, it has become the custom to fire chilled shot, instead of shell, at an obliquely placed target; and as the shot is of a somewhat different form, with its centre of gravity thrown further forward, the results attained by it have been better than those attained by the shell. But this partial success is gained only by the abandonment of the most successful instrument of naval warfare. No one who has a competent knowledge of the subject can doubt that we should in every case aim, not at the substitution of shot for shell, but at the substitution of shell for shot.

Five years have now elapsed since the 7 in. gun competition to which we have frequently referred, and it is clear that any improvements in the minor details of our ordnance could by this time have been effected, and that continued failure can be due only to some radical defect in the system. It may be said that there is nothing easier than the task of the critic who lays bare a fault but cannot suggest a remedy. To this we answer not only that we have already pointed out the remedy, but that a preventive was in the hands of the committee when the rival systems were submitted to them. Having to choose between a plan at once sound and economical and a plan at once unsound and expensive, they deliberately preferred the latter to the former, though they appropriate some of the ideas of an unsuccessful competitor. The remedy was the Scott system of rifling ordnance. In this, it will be remembered, there are three leading characteristics. These are an even, instead of a gaining, twist in the rifling, a peculiar groove, invented by Captain Scott, narrow, shallow, rounded, deeper on the bearing than on the loading side, and a projectile with iron flanges cast in one with itself. The principle of centring the shot in the gun, it is well known, was originally pointed out and applied by Captain Scott, and we are not aware that it has been anywhere so well put in practice as in Captain Scott's own system.* It was he who first suggested that there should be less windage over the bearing part of the projectile than over its body, so as to keep the body of the shot from contact with the bore of the gun; and this, in combination with his peculiar groove, has the effect of carrying the shot and shell with a steady motion through the centre of the gun, with the gas equally distributed above and below. Accuracy in shooting is necessarily increased by this device, and a greater range is attained at all elevations. The trajectory of the ribbed projectile fired from the Scott gun is low, its initial velocity high, its steadiness and penetrating power very great. The iron flanges have an effect directly the reverse of the stud-holes adopted in the Woolwich system. They give strength instead of weakness to the projectile, and preserve, instead of injuring, the rifling. They run no danger of breaking up, either within the gun or on their first impact upon the target; above all, they are specially adapted for use as shells. The fact that the missiles are cast whole, with buttresses, so to speak, upon their outer walls, not only renders them secure from fracture, when made of the service thickness, but would bestow upon them the same immunity when made much thinner, and, therefore, gives a far greater powder capacity than that of the Woolwich projectile. We have from the first pointed out that in the 7 in. gun competition the balance of advantages lay with one gun. We now maintain that with every increase in the weight of our guns and projectiles, the balance in its favor is increasing. Had the ribbed projectile system been adopted from the first, we should, in all probabilty, not have heard of guns disabled by their own projectiles, of shells turning over and over in the air, of contrivances to save ships and crews from the dangers of their own guns. All these disasters show that there is something radically wrong, which no trifling change of detail can set right. The first cost of the projectiles is enormous; both projectiles and guns seem to delight in adding to the expense by a process of mutual destruction. It is high time that something were done to curtail this reckless outlay. We do not pretend to be omniscient, or to predict what will be the

* See Holley's text-book on "Ordnance and Armor."

cheapest gun of the next century, but we do know that the Woolwich system of ordnance is neither the best nor the cheapest which can be adopted. In our impression of January 11, 1867, we gave a table showing the comparative merits and cost of the Scott gun and its rival. We will only add that the disparity between the two would be greatly increased in the 25-ton gun. In rifling the Woolwich gun, the cost per groove is £1 16s.; in the Scott gun the cost per groove is only 17s.; and we believe fewer grooves would be required in the Scott than in the Woolwich gun. Even for the 7 in. gun, the cost of the Scott shell was £68 per thousand less than that of the Woolwich or French shell, and the cost of the Scott shot £83 per thousand less than that of the Woolwich or French shot. The expense of the stud system is in itself so great, and the number of studs required for the heavy projectiles so large, that the economy effected by the ribbed system would be far greater than is apparent from these figures. On every ground, then, we hope the time is not far distant when a new trial will be made. We ask no more, and we will be satisfied with nothing less. We are very far from advocating the immediate adoption of the Scott gun into the service without further question; but we do assert that the existing system of rifling having, as we predicted it would, proved a failure, the Scott system should now have that further trial to which it has long since proved itself to be entitled.

Apart from the question of economy, the subject is one of the greatest national importance. Our prestige is at stake in more ways than one. Not only have we to maintain our supremacy at sea, but it is also most essential that we would not lose our reputation abroad as naval engineers. It happens unfortunately that the mishaps which have occurred through the adoption of the gaining twist and the stud-shot have been repeated in the Italian navy, in which our system has been copied. Foreign nations are already learning to build their own ships; a few more lessons like that which the Italians have just learned will do irreparable mischief both to our trade abroad and to our own confidence in our resources. England cannot afford to have it said that she does not understand the principles of modern naval warfare; and we trust we shall ere long see the introduction of some plan which shall be correct in theory and effective in practice.

We hope the warnings of past experience will not be forgotten, and that when a new committee is appointed the military element will be properly balanced, both by naval officers who have a special knowledge of the subject, and by some of the ablest of our civil engineers.

ON COAL MINING IN DEEP WORKINGS.

From "The Mining Journal."

In this communication the principal conclusions arrived at were:—

Judging from the statistics of the past few years, the production of the British coal fields could not be considered to increase annually in a constantly increasing ratio, as had been surmised, but might be estimated at an average output of 105 millions of tons yearly. Estimating the coal remaining in the British Islands to a depth of 4,000 ft. to be 37,300 millions of tons, this quantity of coal would supply the annual demand of 105 millions for 355 years; and, taking the limit to deep mining to be a depth from the surface of 7,000 ft., the further quantity of coal estimated to be workable to this depth was 57,222 millions of tons, which would extend the supply for a further period of 535 years. The chief localities in the British Islands where coal would probably be found at greater depths than had hitherto been reached were (1) the West Coast of Ayrshire (2), the West of Lancashire (3), the East of Yorkshire, Derbyshire, Nottinghamshire and Staffordshire, and (4) below the seams worked at present in the South Wales basin.

Deep mining had been carried on much more extensively in Belgium than in England, there being only 12 pits of a greater depth than 1,500 ft. in the latter country, as compared with 68 in the former. The deepest coal mine in the

world was probably that of Simon Lambert, in Belgium, which had attained the great depth of 3,489 ft. The deepest coal mine in England was the Rosebridge Colliery, in Lancashire, which had reached a depth of 2,418 ft., the temperature of the coal at that depth being 93.5 deg. The distance from the surface of the ground to the stratum of invariable temperature might be taken at 60 ft., and the constant temperature at that depth at 50 deg. The accounts published between 1809 and 1840 of several hundred experiments relating to the temperature of coal and metalliferous mines showed the increase of temperature to vary from 1 deg. for every 45 ft. to 1 deg. for every 69 ft.; the distance from the surface at which the experiments were made varying from 100 to 1,700 ft. The results of more recent experiments in England and on the Continent were irregular, and showed an increase varying from 1 deg. for every 41 ft. to 78 ft. the distances from the surface being from 700 to 2,600 ft. On comparing the experiments made at the two deepest English mines—Rosebridge and Dukinfield—it was found that the increase of temperature due to depth was much less rapid at the latter colliery than at the former; and this difference was assumed in a paper read recently by Mr. Hull, to be due to an amount of heat being lost at Dukinfield, owing to the heavy inclination of the strata, which was about 1 in 3, whilst at Rosebridge the coal seam was nearly level. The relation of the position of the bottom of a mine to a sea level influenced the temperature, as shown in accompanying tables. In one table the average increase of the temperature of 3 mines of a high elevation was 1 deg. for every 71.6 ft., whilst the increase for 3 mines at some distance below the level of the sea was 1 deg. for every 62.3 ft.

The experiments relating to the underground temperature of the air at the Rosebridge Colliery showed an increase in the temperature of the air in passing from the downcast to the upcast shaft of from 55 deg. to 63 deg.; the air passing through workings the temperature of which was 78 deg., and the normal temperature of the coal being 93.5 deg. The experiments at Monkwearmouth showed the effect of a large volume of air in preventing a rise in temperature. At a distance of 1,800 yds. from the shaft, with 80,000 cubic ft. of air passing per minute, the temperature was 55 deg., whilst at a distance of 2,600 yds. from the shaft, with 10,000 cubic ft. of air circulating per minute, the temperature was found to be 67 deg.

The normal temperature of the coal might be estimated, from the results of experiments at Seaham Colliery, to exist in a main air channel, which had been exposed to the air for some time, at a distance of about 13 ft. from the surface of the mineral. The highest temperature at which coal mines were worked was probably in Staffordshire and at the Monkwearmouth Colliery, where the temperatures varied from 80 deg. to 85 deg. At the Clifford Tin Mine, in Cornwall, the temperature was 120 deg., in which the miners could only work for 25 minutes consecutively, this high temperature being due to the heat of the water issuing from the rock. It would appear from the contradictory results of the experiments relating to the temperature of different minerals that no rule could be laid down. It was probable, however, that the temperatures of mines was affected to some extent by the varying conducting power of different minerals.

In regard to the increase of temperature with the distance from the surface, a careful comparison of all the experiments quoted and especially of those taken at a greater depth than 2,000 ft., led to the conclusion that, as far as could be judged from the experiments already made, the increase of temperature would be 1 deg. for every 55 ft. in depth, from the stratum of invariable temperature. The data afforded by the experiments were so irregular that no law could be established as to the ratio of increased temperature, augmenting or decreasing with increased distance from the surface, though the experiments at South Hetton and at Mouillelonge, as recorded in the paper, appeared to indicate that the rise in temperature became more rapid as the distance from the surface increased. Assuming the rate of increase in temperature to be as previously estimated, the normal temperature of a mine 7,000 ft. deep would be 176 deg.

Of the 3 modes by which heat was lost by one substance, and absorbed by another —radiation, conduction, and convection— the only influence likely to come into action in a well-ventilated mine of the

depth stated would be that of convection. From the observations recorded, it would seem that, as a rule, when the temperature of the surface exceeded 66 deg. the temperature at the bottom of the pit was less than at the top, but when less than 66 deg. at the top of the pit an increased temperature was found at the bottom. The increase in the temperature, due to the increased density of the air in deep mines, was estimated at 1 deg. for every 800 ft., making the mean temperature of the pit 7,000 ft. deep above 50 deg.

The effect of the heat emitted by workmen, candles, explosion of gunpowder, etc., was estimated not to have any appreciable influence on the temperature of the air circulating in the mine. The experiments at Seaham showed the temperature of the return air to be 0.5 deg. *lower* when the mine was in full operation than when the pit was off work, and when no lamps, workmen, etc., were in the workings. An unexplained cause of high temperature had been observed at several collieries, but more particularly at Monkwearmouth, where the temperature of the air on one occasion was found to be 95 deg., or upwards of 10 deg. higher than the normal temperature of the mineral. The question as to the effect of pressure upon deep workings was unquestionably of great importance, and necessarily very speculative. The mode of working coal, suggested for a depth of 7,000 ft., was arranged as far as possible in accordance with the principle that the coal should be removed so as to present long lines of fracture, and should be so worked as to cause the superincumbent weight of the strata overlying the goaf, or space where the coal was worked out, to have all its pressure upon such goaf, and a minimum pressure upon the coal. The increase in temperature in an underground air channel appeared to average about 1.5 deg. for every 500 yards.

The question of ventilating a mine 7,000 ft. deep to an extent sufficient to absorb the heat emitted by strata having a normal assumed temperature of 176 deg. was one of the most important in the inquiry, and the general results arrived at might thus be enumerated :—1. The temperature of the air was estimated to increase from 59 deg. at the bottom of the downcast pit to 65 deg. at the point where it reached the workings.—2. The length of time which would be occupied in cooling the main air-way to such an extent that the sides of the road would have an average temperature of 62 deg., and the normal temperature would be found as far as 12 ft. from the surface of the mineral, was calculated to be 40 days.—3. The total number of units of heat emitted by the strata per minute was found by calculation to be 45,320.—4. The volume of air introduced at the temperature of 65 deg., and assumed to leave the workings at a temperature of 89 deg., necessary to carry away this number of units of heat, was calculated to be 73,000 cubic ft. per minute.—5. Then, taking the total quantity of air necessary for the ventilation of the pit to be 110,000 cubic ft. per minute, the power required to produce this quantity would be 141 H. P., which represented an average temperature in the upcast pit of 90 deg., for the attainment of which mean temperature a temperature of 141 deg. was required at the bottom of the upcast pit.—6. The quantity of fuel necessary to raise the temperature of the return air from 96 deg. to 141 deg. was found to be 14.04 tons every 24 hours.

The laws upon which the amount of power necessary to produce a certain quantity of air under every condition was stated to be as follows : The pressure per unit of sectional area of an air-way required to overcome the friction of the air, varied directly as the length of the air channel, as the length of the perimeter, and as the square of the velocity of the air, and inversely as the sectional area of the air-way. The action of these laws was demonstrated in the several examples given, where it is shown that the power required to overcome the resistances varied as the cube of the velocity. In drawing a comparison between furnace and mechanical ventilation, it is calculated that at a depth of about 2,500 ft. the two modes of ventilating were equal, while below this depth the furnace became the more effective power.

In regard to the raising of coal, the probable limit from which it might be drawn at one lift was estimated to be about 900 yards, below which depth one winding-engine at the surface and one in the shaft would be required. An increase in the cost of sinking to great depths, and in the cost of producing the coal, must necessarily be expected ; but since the

selling price of coal would, to a great extent, be adjusted accordingly, this could scarcely be considered as a difficulty of much consequence.

The employment of machinery in place of manual labor would, probably, be found very beneficial in cutting and breaking down coal in deep mines having a high temperature. Some of the coal-cutting machines now at work were driven by compressed air, and the sudden decrease in temperature which compressed air underwent on exhaustion had been thought likely to be of use in reducing the temperature of a mine. In reality, however, scarcely any reduction could be anticipated, since the quantity of air exhausted bore so small a proportion to an ordinary current of air, that the effect on the temperature was only to be observed locally, and to a very slight degree. Of other modes which had been proposed for facilitating the working of coal at great depths, neither that of casing the air-ways with non-conducting substances, nor the employment of the electric light, nor the use of cold water and ice, could be anticipated to have any effect worthy of note. The hygrometrical experiments recorded showed that the dryness of the air was considerably increased with increased depth, especially in the return air-courses ; and though this usually caused a high temperature to be borne more conveniently, it could not, in the case of the heavy labor required in working coal, be calculated to confer any benefit.

Finally, it might be stated that the question of working coal at greater depths than had hitherto been attained could not be considered to be one which presented difficulties of any importance, nor was it one which required immediate consideration.

The author had endeavored to prove that coal could be worked at a depth of 7,000 ft., but it would probably be centuries before such a sinking would actually be required, and improvements in the various descriptions of mining machinery, especially such as were intended to facilitate the getting of coal, would possibly before long render mining to such a depth as practicable as the workings of deep mines of the present day. Commercially, as had been observed, the question would adjust itself to the requirements and expenditure of the times.

PHYSICAL THEORY OF THE PRINCIPLE OF THE LEVER.*

By PROF. W. A. NORTON, of New Haven, Conn.

If it be true that two forces acting upon a lever will hold each other in equilibrio if their intensities be inversely proportional to their lever arms, it is plain that this principle must be a consequence of the law, or laws, of the lateral transmission of force from molecule to molecule of the lever, and therefore of one or more fundamental principles of molecular action consequent upon the disturbance of the natural equilibrium of the molecules. I propose to show that it may in fact be deduced from two admitted principles of molecular action. These are :

(1) If two integrant molecules of a solid body, which lie within the range of reciprocal action, be forcibly separated from each other a minute distance, a mutual attraction or repulsion will be brought into operation, and if they be urged nearer to each other by an equal minute distance an equal opposite force of repulsion or attraction will come into play.

(2) The intensities of the forces thus originating are proportional to the amount of the relative displacement of the two molecules, on the line connecting them.

To these fundamental principles are to be added that of the parallelogram of forces, as applicable to the case of two forces acting *directly* upon the same point.

The principle of the lever presents three distinct cases, which require separate consideration.

1. *The Straight Lever, with perpendicular forces.*
2. *The Straight Lever, with oblique forces.*
3. *The Bent Lever.*

Case I. *The Straight Lever, with perpendicular forces.* We will first take the lever of the first order, and consider the precise process of transmission of either of the extraneous forces acting upon it from the

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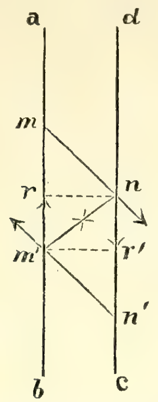
point of application to the fulcrum. Let *ab*, Fig. 1, represent a vertical line of

Fig. 1.



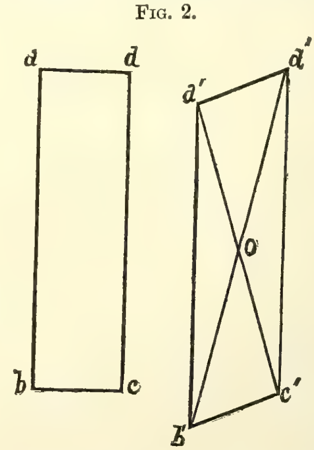
particles of one cross section, or lamina, and *cd* the contiguous vertical line of particles of the next section ; and let us conceive that all the similarly situated pairs of lines of the two cross sections or laminæ, are concentrated upon *ab* and *cd*, so that these lines may represent the entire cross sections.

Suppose that the extraneous force is directly applied to the first line, depressing it by a small amount. If we take one particle *m'* of the first line and consider the actions upon it of two particles *n*, *n'*, of the second line at equal distances above and below it, it will be seen that *m'* will recede from *n* a minute distance, and approach *n'* by sensibly the same distance, and that the molecular forces brought into operation by these relative displacements will be opposite in their character, and equal in intensity. Thus, if the recess of *m'* from *n* develops a mutual attraction, the approach of *m'* to *n'* will develop an equal repulsion. The resultant of these two forces acting on *m'* will be directed upward, or from *m'* towards *a*. A similar result will be obtained for each pair of particles, *n*, and *n'*, that exercise a sensible action on *m'*; except for those situated beyond a certain distance the forces developed, and consequently their resultants, will be reversed, or *m'* will be urged downward by the actions of such particles. Since *m'* is held in equilibrium in opposition to the extraneous force urging the section *ab* downward, the entire resultant of all the actions of the pairs of particles *n*, *n'*, of the section *cd*, on *m'*, will be directed upward. The section *ab* slips upon *cd*, under the action of the extraneous force until this resultant is equal to the extraneous force. By our second fundamental principle the amount of this slipping will be proportional to this force; since the actions of each pair of particles, *n*, *n'*, will be proportional to this displacement.

Now if we take any particle *n* of the section *cd*, and consider the actions on it of two particles *m*, *m'*, at equal distances above and below *n*, and at the same distances that *n* and *n'* are above and below *m'*; then, if the actions of *n* and *n'* on *m'* are such as to give a resultant directed upward, the actions of *m* and *m'* on *n*, will give a resultant directed downward, as shown by the arrows in the figure. These two resultants will be equal to each other. It follows, therefore, that the entire action of *ab* on *n* will be represented by a force acting downward equal to that by which *m'* is drawn upward by the action of *cd* upon it. This force will then be equal in intensity to the extraneous force. Accordingly the extraneous force will be transmitted from *ab* to *cd*; and in the same manner from this section to the next, and so on to the point of support. The transmission is effected by the slipping of each vertical section, or lamina, by the same amount upon the next, and so developing reciprocal vertical actions equal to the extraneous force.

Let us next seek to determine the longitudinal strains on the fibres, developed by

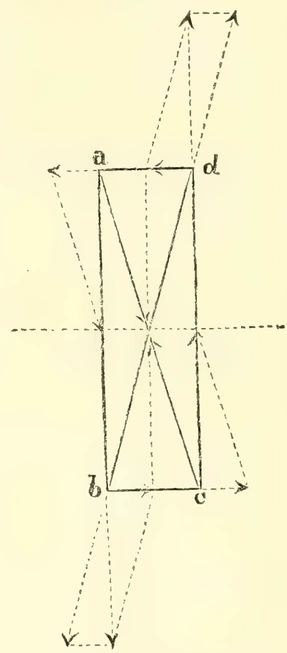
Fig. 2.



the extraneous force in the process of lateral transmission just considered. Let *ab* and *cd*, Fig. 2, represent two vertical

cross sections of the lever indefinitely near to each other, of which *ab* directly receives the force applied to one end of the lever. The relative slipping of contiguous laminæ causes the rectangle *abcd* to take the figure of an oblique parallelogram, *a′b′c′d′*; the diagonal *ac* being shortened, and the diagonal *bd* being lengthened. It therefore develops forces of compression taking effect from *a′* and *c′* toward the centre *o* of the parallelogram, and forces of extension taking effect from *o* toward *b′* and *d′*. The reactions to these forces take effect from *o* toward *a′* and *c′*, and from *b′* and *d′* toward *o*. These reactions will urge the points *a′* and *d′* toward the left, and the points *b′* and *c′*, toward the right; and the longitudinal strains on the fibres *a′d′* and *b′c′*, thus originating at the angular points of the parallelogram, will be equal. For, supposing that there are only these extreme fibres, and that the diagonals *a′c′* and *b′d′* are material lines, the figure *a′b′c′d′* is to be regarded as a system in equilibrium under the action of two equal forces along its vertical sides; that along *a′b′* being the active force and directed downward, and that along *c′d′* being the equal reaction of the fixed support transmitted to *c′d′*, and directed upward. One-half of each of these vertical forces will act at the upper and lower corners of the parallelogram. The reactions along the diagonals, above alluded to, will at these points sustain the equal vertical forces acting on them, and at the same time develop equal longitudinal strains on the fibres *a′d′* and *b′c′*. Or, more directly we may regard the equal vertical forces, at the four angular points, as taking effect at the same time along the diagonals and along the fibres. This is illustrated in Fig. 3, in which the vertical forces soliciting the angular points of the parallelogram are represented by the halves of its vertical sides, or by equal lines. It will be seen that the longitudinal strains developed at these points will be represented by the halves of the horizontal sides; and therefore that the entire strains on the extreme fibres, due to the parallelogram considered, will be represented by these sides, *ad* and *bc*. If now we take the case as it actually is, and regard the entire area, *abcd*, as made up of fibres, the only result will be that the longitudinal strains, which upon the previous supposition would be developed along *ad* and *bc*, will be distributed over all the fibres lying between these extreme fibres and the middle one. What the law of the distribution may be it does not concern us now to inquire. It is plain that the individual strains will decrease from the outer fibres toward the middle one, where there will be no strain.

Fig. 3.



If now we take another vertical section indefinitely near to *cd*, it will form with *cd* another parallelogram, the vertical sides of which will be solicited, in opposite directions, by the same forces as those of the parallelogram just considered. The same strains as before will therefore be developed along the upper and lower fibres by these forces. The same will be true of each successive parallelogram into which the arm of the lever may be divided. The actual strain along any one continuous fibre, at the fulcrum, will therefore be equal to the strain on this fibre developed by any one of the parallelograms, multiplied by the number of parallelograms in the extent of the arm of the lever. Now if we suppose the two lever arms to be of unequal length, whatever may be the comparative intensities of the two forces that balance each other, each will give rise to a slipping of contiguous vertical sections, or laminæ, of its lever arm, proportional

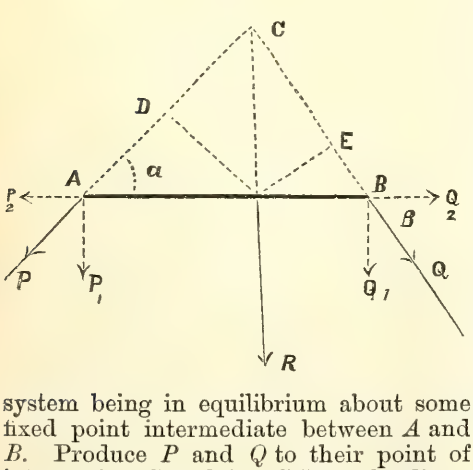
to those intensities, and so develop longitudinal strains on any fibre, in the extent of any single parallelogram considered, proportional to the same. Let p and q represent these proportional strains on a single fibre, and P and Q the forces applied to the lever, then $p : q :: P : Q$. Let m represent the arm of lever of P, and n that of Q. The number of equal parallelograms contained in these lever arms will be proportional to their lengths, m and n. The strain on the fibre considered, at the fulcrum, resulting from the action of P, will then be denoted by pm, and that resulting from the action of Q by qn. But the equilibrium requires that these directly opposite strains should be equal; and therefore $pm = qn$. Hence $p : q :: n : m$; and therefore $P : Q :: n : m$.

Since each of the forces P, Q, is transmitted to the fulcrum, by the slipping of each vertical section of the lever on the next, without change of intensity, the pressure there will be equal to the sum of P and Q.

The theory of the lever of the second order, as well as of the third, is essentially included in that of the lever of the first order; since the reaction of the fulcrum of the latter may be replaced by an active force, and either of the forces P, Q, by the reaction of a fulcrum.

Case ii. *Straight Lever with oblique forces.* Let AB, Fig 4, represent the lever, and P, Q, forces obliquely inclined to it,—the

Fig. 4.

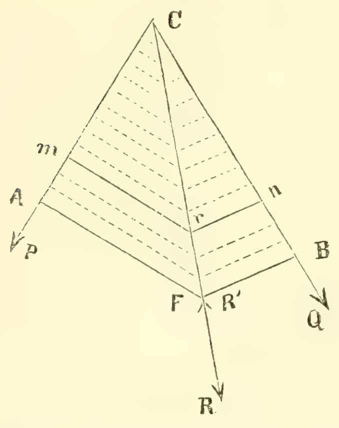


system being in equilibrium about some fixed point intermediate between A and B. Produce P and Q to their point of intersection C, and let $C F$ be the direction of their resultant R, supposing them, for the moment, to act at C. Wherever the fulcrum may have to be, in order that P may balance Q, P and Q will be transmitted to it, by the process of molecular lateral transmission that has been explained, without change of direction or intensity, and therefore give a resultant pressure R', on it, having the same intensity and direction as R acting at C. Decompose P and Q as shown by the arrows, and suppose R' to be similarly decomposed into the components R_1 perpendicular to the lever, and R_2 lying in it. Then, since R' is the resultant of P and Q transmitted to the fulcrum, we have $Q_2 - P_2 = R_2$, and $P_1 + Q_1 = R_1$. Thus P_2 and Q_2 are neutralized by the component of the reaction of the fulcrum (which is equal and opposite to R') in the direction of the lever; since this component is equal and opposite to R_2. It follows, therefore, that the two components, P_1 and Q_1, perpendicular to the lever, will balance each other about the fulcrum. It now remains to be seen where the fulcrum must be situated, in order that P_1 may balance Q_1. From F, where the line of direction of R, through C, cuts $A B$, draw $F D$ and $F E$, perpendicular, respectively, to P and Q, then by the parallelogram of forces, $P : Q :: F E : F D$;—and therefore P and Q may be represented by $F E$ and $F D$. Now $P_1 = P \sin a$, and $Q_1 = Q \sin \beta$; and $\sin a = \frac{F D}{F A}$, and $\sin \beta = \frac{F E}{F B}$. Hence $P_1 = P \frac{F D}{F A}$, and $Q_1 = Q \frac{F E}{F B}$; or $P_1 = F E \frac{F D}{F A}$, and $Q_1 = F D \frac{F E}{F B}$. Therefore $P_1 : Q_1 :: F E \frac{F D}{F A} : F D \frac{F E}{F B} :: \frac{1}{F A} : \frac{1}{F B} :: F B : F A$. The fulcrum is therefore at the point F, where the line of direction of the resultant R, of the forces P and Q supposed to act at C, cuts the lever. But we have already seen that $P : Q :: F E : F D$. Hence these forces are inversely proportional to their technical lever arms, $F E$ and $F D$. As P and Q are transmitted to the fulcrum without change of direction or intensity, the pressure on the fulcrum will be equal to R.

Case iii. *The Bent Lever.* Let P and Q, Fig 5, be two forces acting on two points A and B of a body of indefinite extent, capable of turning about a fixed point F, situated in the plane of the lines of direction of P and Q. Produce these lines of direction to their point of intersection C;

and from F draw the perpendiculars $F\,A$ and $F\,B$. Divide $F\,C$ into an indefinitely great number of equal parts, and from the points of division draw parallels to $F\,A$ and $F\,B$. Let us first suppose that the point C falls within the body, and that this is of uniform thickness in a direction perpendicular to $A\ C\ B\ F$, and has the form $A\ C\ B\ F$. The perpendiculars to P and Q, from the points of division of $F\,C$, will divide the body, conceived to be represented by the area $A\ C\ B\ F$, into an indefinite number of similar portions of the bent lever form, with the points of intersection of the two arms on the line $C\ F$. Now let a represent the cross section of any one of these, on the line of P, and b the cross section of any one on the line of Q. P will be equally distributed

FIG. 5.



over the entire cross section $A\ C$, and Q in the same manner over $B\ C$. Let p and q denote the fractional portions of P and and Q that take effect at the ends of any one of the bent lever portions of $A\ C\ B\ F$. If we consider any one of these portions by itself, it will be solicited by the forces p and q, and be in equilibrium under the operation of these forces and some portion of the reaction R', to the pressure R, on the fulcrum, produced by P and Q. They will be transmitted inward by the slipping of contiguous sections, and neutralized by a certain portion of R′ transmitted along its line of direction; and the point in which this line intersects the bent lever portion under consideration must be its virtual fulcrum. Now if we consider the bent portion next to C, its fulcrum must be indefinitely near to C; while that of the first elementary bent lever, $A\ F\ B$, lies at F. But all the fulcra of the elementary levers must lie on the line of direction of R', which passes through F. Hence, as C is the fulcrum of one of these levers, this line of direction must also pass through C. Now the direction of R' is opposite to that of the resultant R, of P and Q supposed to act at C; since R' neutralizes P and Q transmitted, without change of direction or intensity, to F. Therefore, as its line of direction passes through C, it must coincide with the line of direction of the resultant R, of P and Q supposed to take effect at C. It follows, then, that the fulcrum F, lies on this resultant. But, by the principle of parallelogram of forces, we have, for any point, F on the resultant, the proportion $P : Q :: F\,B : F\,A$.

Now suppose a portion, $C\ m\ r\ n$, of the body $A\ C\ B\ F$, to be removed; the equilibrium will not be disturbed, since the only effect will be to augment the intensities of the fractional parts of P and Q that act on the elementary bent levers of the remaining portion, $m\ r\ n\ B\ F\ A$, without altering their ratio. Hence the forces, P, Q, which act on a bent lever and hold each other in equilibrio, are inversely proportional to their lever arms.

It will be seen from what has been stated, *in what manner the forces P and Q become neutralized by the action R′, or the reaction of the fulcrum.* Even when their point of intersection, C, falls within the body, they cannot be regarded as actually transmitted to C, and taking effect wholly there in opposition to R' transmitted and taking effect wholly at the same point. As a matter of fact it is only an infinitesimal portion of each force that operates at C. An equal indefinitely small portion p, q, or r, acts upon each elementary lever; and each triplet of forces taking effect on each elementary lever, counteract each other. In other words, the forces P and Q, instead of taking effect by direct transmission, wholly either at C or F, are actually distributed along the whole length of the portion of the line $F\ C$ that falls within the lever, and are there neutralized in equal elementary portions, by the corresponding elementary portions of R', transmitted to the same points.

If we suppose the body on which P and Q act, to have an indefinite extent, the only portion whose molecular forces will be called into play, in the transmission

and counteraction of the forces, will be that comprehended within the lines of direction of P and Q. This will comprise the part $A\ C\ B\ F$ already considered, and another part lying on the other side of $A\ F\ B$, that is on the side toward which P and Q solicit the points A and B. This part may be subdivided into elementary bent levers like the other, and its existence will have no other effect than to diminish the absolute values of p, q, and r, the triplet of forces answering to any one of the whole number of elementary levers, into which the entire portion of the body that lies within the lines of direction of P and Q is divided. It will be observed that for each elementary lever of this part, the resultant of the forces p and q will take effect upon the fixed point F, as a force of traction, instead of as a force of pressure, as in the case represented in Fig. 5.

We thus arrive at the general principle, that if two forces, whose lines of direction when produced intersect each other, are applied to a body capable of turning about a fixed point in the plane of these lines, these forces will be in equilibrio, provided *the statical moment of the one force is equal to that of the other.*

THE LAWS OF SEWAGE AND OTHER FERTILIZERS.

From "The Engineer."

Notwithstanding all that has been said on the subject, the utilization of sewage by irrigation is a process very much misunderstood, and there is danger least a prejudice should be raised sufficiently powerful to prevent the progress of a great sanitary and agricultural reform.

In the first instance, we will refer to some rather curious facts which may seem to tell against the principle we are defending, and which might be turned to great account by the opponents of sewage irrigation, though the facts, so far as we are aware, have not yet been prominently brought forward.

Every reader in his rural rambles will have noticed that pasture land is frequently dotted about with tufts of grass, growing in rich luxuriance, but which seem strangely neglected by the animals feeding in such fields. This ordinary phenomenon will be found to arise on pastures where there are cows only, or horses only. Where cows and horses feed together, these lumps of grass, which give the field an untidy appearance, are not perceptible. The explanation afforded is as follows :—Grass fertilized by cow-dung is repulsive to cows ; grass fertilized by horse-dung is repulsive to horses; but contrariwise, grass fertilized by horse-dung is acceptable to cows, and grass fertilized by cow-dung is acceptable to horses. Hence, if both classes of animals feed together, the pasture is cleared, but not otherwise. The question arises, whether there is not here some law of nature which forbids that an animal should feed on vegetable matter built up from the excreta of the species to which the animal belongs. Chemistry would say that the elementary bodies which enter into the constitution of a plant are the same, let the source of such atoms be what it may ; yet, on the other hand, it is well known that the flesh of an animal is affected by the character of its food. There is "one flesh of men, another flesh of beasts, another of fishes, and another of birds." Yet, "while all flesh is not the same flesh," who has not tasted fishy pork and fishy birds? May not, then, the tissues of a vegetable be affected by the nature of the food upon which it has fed? May not the essential atoms and the specific structure be associated with compounds varying according to the character of the source whence those essential atoms were derived? A given volume of water in the Thames may have obtained part of its bulk from the liquid sewage of a town ; the sewage itself may have been thoroughly oxygenized, so as to have entirely disappeared ; yet certain nitrates and nitrites existing in the water of the river, will show that its previous history differs from the antecedents of a stream among the Welsh mountains. The nitrates may or may not be injurious, but, in any case, their presence is a peculiarity. May not some peculiarity attach to plants according to the nature of the manure on which they were reared? It may be said that the cow or the horse is simply repelled by the

smell of its own dung, and has no real distaste for the grass. The answer is, that the aversion continues until some considerable time after the disappearance of the dung, although the dislike becomes less marked as time goes on. Certainly there is this peculiarity from the very commencement, that each animal will feed on grass fertilized by the dung of the other, while refusing that which its own dung has fertilized. Carrying this law, if it be such, into a higher grade, are we to say that man should reject the wheat reared by the sewage of towns? Should he also reject the flesh of animals reared on sewage farms? With regard to the meat question, we may observe that the horse eats the grass fertilized by the cow, although the cow itself eats grass fertilized by the horse. By parity of reasoning, we may argue it is safe for man to eat the flesh of a bullock which has been fed on Italian rye grass, even though that grass were fertilized by town sewage. If we are rightly informed, cows and other animals are very unwilling to graze where sewage manure is fresh on the land. This aversion exists until the manure has well sunk in the ground, after which all quadrupeds will feed readily on the produce. When cows are fed on Italian rye grass, the grass is generally, if not always, cut in the field, and conveyed to the cows, the animals being kept in sheds. Thus the animals are fed with the cleanest portion of the grass, presuming the land to be irrigated with sewage distributed by open carriers, and not by means of the hose and jet. So far the animal is tolerably sure to be fed on vegetable matter which has thoroughly assimilated the sewage elements. This may, in some measure, answer the objections of Dr. Letheby and Dr. Cobbold, who argue that if sewage is applied to land where animals are fed on green crops, a very serious effect will be produced upon the animals so fed, and upon human beings who eat the flesh of such animals. Nature seems to have given a discriminating appetite to the cow, and, we may presume, to other animals also, so as to guard against the peril which otherwise might prevail. Our information is less complete with regard to the sheep than in the case of the cow; but, we may ask, whence arises that minute "lumpiness" of the turf on the downs where sheep alone are fed? May it not be that these animals have an aversion similar to that of the cow and the horse; and being equally dainty with them in this respect, may be equally cautious in reference to sewage?

But if safe with regard to flesh, is man equally secure in feeding direct on a sewage-grown vegetable? Perhaps this question is partly answered by the fact that where town sewage is not employed, something equally filthy is often used as a fertilizer. The extensive and inevitable use of manure proves that very disagreeable ingredients may help to produce agreeable and wholesome food. If we may not use any manure at all, the fertility of our fields must cease. If we may use one kind of manure, why not another? If the plant can thrive on the manure, why may not the animal thrive on the plant? The disgust of the cow and the horse for the produce of its own manure has its limits, and those limits seem to show that when manure is thoroughly assimilated offence ceases. A soil sodden with sewage, or in any way overstocked with the elements of sewage, may possibly be unfit for the growth of wheat. But, on the other hand, excess of manure, of whatever sort, might be held as dangerous. The true principle appears to be this: That sewage should be applied in moderation, so as not to declare its presence. It has been the common fault first to take a quantity of sewage, and in the next place to try and "get rid of it." Under such a mode of treatment the land deluged with sewage has become a positive nuisance. Many respectable authorities have a notion that town sewage is so highly diluted that a large quantity must necessarily be used; but the result belies the argument; for the land refuses to take so large a dose. The excess of sewage lies upon the ground and pollutes the air. A nuisance is created, and it is a law of nature that where sewage is wasted a nuisance shall be experienced. The utilization of sewage really means that the sewage shall be "used." When sewage is "used" its power of offence ceases. Dr. Letheby refers to Croydon as an example of sewage irrigation; but it is a bad example. Dr. Letheby states that the subsoil water at Croydon is so mingled with sewage that the wells are thereby polluted. This is just so much waste. The sewage ought to be in the plants and not in the wells.

Referring again to the phenomena of the pastures, we would observe that each tuft of grass is an instance of waste. Who would think of covering a field all over with cow-dung 2 or 3 in. deep so as to hide every particle of earth? And why should there be such a depth anywhere? If the cow-dung were mingled with water until it had the strength of ordinary town sewage, and were then distributed over an area sufficient to absorb it, so that in 20 min. no smell should be perceptible. and if liquid manure of this description were applied only once in the course of several days, would there be any difficulty in feeding cows on land thus treated? Would not the grass in such a case resemble that which grows when the ordinary cow-dung has not only disappeared but has really entered into the constitution of the plant? All the phenomena we have mentioned seem to enforce one lesson, namely, that every inch of ground demands the restoration of that which it first gave up, and that to spread on one inch the manure belonging to two is a waste and a misapplication which natural laws resent. Further, we may allow that the rule is particularly strict in those cases where the animal is its own fertilizer. As a corollary it may be asserted that the use of town sewage does not preclude the employment of other manures, natural or artificial. There is particular reason to believe that, in the case of wheat, other manures beside town sewage are needful in order to bring the plant to perfection.

COMPOSITION OF WOOTZ STEEL.

From "The Engineering and Mining Journal."

In the "Industrie Zeitung," we find an analysis of this East Indian steel, by Prof. Rammelsberg, of Berlin.

The Wootz or Bombay steel has been celebrated, from olden times, for its surpassing hardness, which has given it the first place for the manufacture of cutting instruments. According to several authorities, it is made by smelting a pure, sandy magnetic ore in small furnaces, by which means blooms weighing about 40 lbs. are made. These are hammered out, cut into pieces and melted with chips of the *Cassia Auriculata,* an East Indian plant, in a clay crucible with an air-tight cover. Twenty to 24 of the crucibles, each containing only a pound of material, are heated at once in a small blast-furnace, and in each crucible is found at the end of the operation a small smelted lump of cast-steel. It is said that only 12 per cent. of the iron contained in the ore is saved in this way. Wootz steel is therefore a cast-steel, which partially accounts for its good quality.

In 1819, Faraday, in connection with Stodart, undertook an analysis of Wootz steel, which attracted considerable attention from the fact that they found alumina as well as carbon and silicic acid. From this fact they concluded that silicon and aluminium imparted to the East India steel its peculiar properties. They found 0.03 per cent. of silica and 0.7 per cent. of alumina, not in the solution of the steel in aqua regia, but in the black, carbonaceous residue, when subsequently heated to redness in a silver crucible with caustic alkalies. This manner of procedure, in the light of the present advancement of chemical science, is sufficient to place the accuracy of the result in doubt. Karsten, who accomplished so much in iron investigations, found only doubtful traces of aluminium. T. H. Henry afterwards analyzed a sample the genuineness of which was doubted, and found

Graphite................	0.312	per cent.
Combined Carbon........	1.336	"
Silicon..................	0.044	"
Sulphur	0.175	"
Arsenic	0.036	"

but no aluminium.

The collection of the Royal *Gewerbe Akademie* in Berlin contains a sample of Wootz steel, the genuineness of which is guaranteed by a certificate of the East India Company. A portion of this bar was broken off and used by Rammelsberg for his investigations, of which he gave the following account to the Chemical Society of Berlin. The specific gravity is 7.822, instead of 7.728, as given by Henry. It dissolves in hydrochloric acid, leaving only a very small white residue. It contains, therefore no graphite. The solution in

hydrochloric acid gave no trace of copper or arsenic when treated with sulphuretted hydrogen. For the determination of carbon, it was treated with water with the addition of bromine; the carbonaceous residue, when burned in oxygen, left likewise no trace of graphite.

Sulphur was determined by passing the gas generated by the solution in hydrochloric acid through a solution of chloride of silver in ammonia. The dark precipitate was oxidized by means of nitric acid, and after precipitating the silver, the sulphuric acid was precipitated as sulphate of baryta. The nitric acid solution was evaporated to dryness in a platinum vessel, the residue heated alternately in hydrochloric and hydrogen gas, and left after driving off the sesqui-chloride of iron, a residue of silicic acid, which disappeared by heating with fluoric acid. The Wootz contained no trace of aluminum.

The result of the analyses was

Carbon	0.867	per cent.
Silicon	0.136	"
Phosphorus	0.009	"
Sulphur	0.002	"

Henry found altogether twice as much carbon, one-third of which was in the form of graphite. But inasmuch as he had softened the steel, in order to be able to get filings to burn with oxide of copper, it is possible that the softening may have given occasion for the formation of graphite, although Karsten is of the opinion that soft steel contains no graphite. Rammelsberg found three times as much silicon as Henry, and one of Abel's analyses shows that a great deal more may be contained in cast-steel. Henry, furthermore, reports no phosphorus as present, but on the other hand gives arsenic, which is certainly not present at all. Finally, it is to be noted, that Henry gives such an amount of sulphur that the steel would be valueless; for, according to Karsten, wrought-iron containing 0.034 per cent. of sulphur is in the highest degree red-short, and 0.01 per cent. is the boundary for the use of iron.

A great many analyses of iron give, like Henry's, altogether too high a percentage of sulphur, in consequence of the method pursued in its determination. Is there, after all, any such thing as an aluminum steel? Faraday heated steel with coal dust, and the resulting dark grey, foliated product (cast-iron) he heated to a high temperature with pure alumina. He produced a white, fine-grained, very brittle mass, which contained, according to his analysis, 3.4 per cent. of aluminum. When from 6 to 12 per cent. of this was smelted with good steel, the product was a steel possessing the excellent characteristics of the Wootz. The reduction of the alumina, under the circumstances, was very remarkable, and the experiment should be repeated, with the direct use of aluminum, which Faraday could not obtain. The experiment of producing aluminum steel has often been tried but the samples that Rammelsberg has received as such, have always failed to show the presence of aluminum.

Among the many important engineering undertakings in the railway annals of Scotland, the deviation line for the purpose of abolishing the level crossing at Coatbridge may be considered as one of great importance. The chief feature of the new line will be the iron bridge which is to span the present level crossing. It will be built on the same principle as those bridges connecting the streets through which the Union Railway passes in the city of Glasgow, and will consist of massive ashlar abutments 20 ft. in height, with a span of 120 ft., whilst strong malleable iron girders will support the structure. The bridge when finished will cost £6,000. This new line, which will be opened for traffic in a few days, was subjected to a preliminary inspection on Saturday afternoon by a number of the directors and officials of the company, along with Mr. Waddell, the contractor. An engine with 2 carriages left the siding beyond Sunnyside station about 3 o'clock, and passed along the entire length of the line. The inspection was believed to be very satisfactory. The North British Company deserve credit for expending a very large sum of money in order to abolish the very dangerous level crossing at Coatbridge.

Large quantities of bowl sleepers are being made at the Hartlepools, England, for shipment to India; they are intended, of course, for use on Indian railways.

THE THAMES STEAMBOATS.

From "The Engineer."

London is a city of contrasts. The great centre of wealth and of all the refinements and luxuries that follow in its train, it has yet its city Arabs whose squalor and wretchedness would disgrace a Hottentot village, and its eastern districts, whose monotonous and unbroken poverty makes the heart of every honest passer by ache. The source of every great enterprise destined to change the face of either the old world or the new, it is yet the home of the most insensate conservatism, clinging to old habits, old ideas, old systems condemned by all the common sense of a hundred years ago. Rushing with eager haste, north or south, after the objects of its earnest pursuit, its multitudes still put up with street blocks, through restive gas companies, or incompetent vestries, or broken-winded cab horses, or through the freaks of omnibus companies, or a thousand other hindrances just as curable as hunger at a well-spread board. Let a citizen with taste and wealth build himself a commercial palace that adorns his street, ten to one but his neighbor refuses, on any terms, to remove the ugly, dingy pile next door which has been an eyesore for generations. The metropolis maims or slaughters her citizens daily in the streets, but then she provides the most comfortable of almshouses and the most wonderful of hospitals. She has the most gorgeous of lord mayors, the most renowned of aldermen, the most active of vestries, the most potent Board of Works, lords many, and officers more; but if your dustman is restive, who shall say how he is to be reduced to reason; or if the Brighton Railway carries you through the most pestiferous of stenches day by day, and year by year, whence shall come the remedy? Most advanced of Liberals are we of the City, and have bearded sovereigns and baited Papists from the days of old; but as for adapting our city government to the wants of to-day, we should as soon think of it as of giving up the Lord Mayor's old state coach. We have "purified" the Thames, but it is at the cost of polluting Barking. We have built a noble river wall, but then we hand a good portion of the gain to the Duke of Buccleuch and the Metropolitan District Railway. We have spent some three millions on a noble palace for our River Bank, but it is all going to decay because we would not have a man at two pounds a week to see that decent stone was used in its construction. We employed the best talent the country could furnish to design and build our palace, and now we hand it over to "the noble savage" to do with it as seemeth good in his eyes. We have recently erected the handsomest of bridges across our river, but then we had taken care to have the ugliest of structures to run by its side. Our noble Thames is the trading highway of all nations whom we tempt by the chances of gain; but are there anywhere such scoundrels ashore who waylay the helpless visitant, cheating him, plundering him, and all practically unchecked by law or police? Could even the most worldly-wise native undertake to visit a vessel lying midstream without being plundered by the boatmen? But what do our rulers? It seems scarcely reasonable to expect they should protect native or foreigner.

Of all the mean, shabby, disreputable things, embodying the discomforts, the helplessness, and the ugliness of a bygone day, commend us to our river steamers. We have banished our old ramshackle piers—at least the most outrageous of them—thanks to the Embankment, but alack for the boats that come alongside the new structures. It is not fate, but the Citizen Company, that condemns us to sit on a blazing deck, or to descend into a stifling hold, knocking one's head withal at its depressed entrance, and against its low ceiling at every step, unless rejoicing in a stature of five feet nothing, or blessed with a flexibility of the spinal structure beyond the wont of most men. Why the Thames boats should not have the comfort of an awning on deck in hot weather is inscrutable to us, or why the cabins of these boats should not be easy of access, and comfortable when reached, we really cannot tell, except that such reasonable attentions to the wants of passengers are not after the ways of Englishmen, till they are compelled. There seems to be a residuum of insular surliness even in the members of a metro-

politan company, which says: "We carry you people to be sure, and we will make our dividends out of you ; but as for studying your comfort, or dealing with you in a suave and pleasant way, not a bit of it ; we will just be civil enough to decoy you into our dens, and then our spleen and bile shall scatter spray over you, and expose you to the glare of the sun, and cramp you in low cabins, and disgust you with the presence of all ugliness, and the absence of all elegance, because we delight in it, and the masses were designed by Heaven for the sport as well as the support of the few."

A Thames steamboat is easily capable of every desiderated appliance. She might be roomy, lofty, airy, sheltered, abounding with convenience and comfort ; she might even be elegant, built with good proportions, correctly planned, adapted to all the needs of her traffic ; she might even further be beautiful with art in her fittings, and art in her decorations, and art in her appliances. And well would it repay some one to inaugurate this new era. The old manner is said not to have paid very well—pity if it had. The new would, nevertheless.

It is hopeful to see just the scintillation of a sign that even the Citizen Steamboat Company will be compelled to "move on." Formerly to get from the Temple Pier to London Bridge one had to take one boat to St. Paul's Pier and another to the Surrey side. The Metropolitan Railway has already cured that. The same boat now goes the whole journey. We accept the sign as the opening of a new epoch. The spirit of competition is working over the "silent highway," from time immemorial the manor of monopoly. Let the Metropolitan Railway get to London Bridge, and compete along its whole line with those old weird creatures of "Citizen boats," and sundry other signs of healthy competition will soon appear. Taste, progress, even self-interest were powerless to effect the work that buds at the first touch of competition. We are not without warm hopes before very long to have the pleasing duty of presenting to our readers drawings and descriptions, not of a new and luxurious yacht for the Khedive, or even of a more elegant though less luxurious steam yacht for her Majesty, but of a handsome and commodious Thames penny steamboat.

The quantities of railway iron exported from the various ports of the United Kingdom during the month of May last reached, the "Times" states, the large total of 131,208 tons, as compared with 87,392 tons in May, 1869. Out of this Russia took no less than 82,741 tons, against 23,120 tons in May, 1869, and 10,011 tons in May, 1868. The United States also took 33,175 tons, as against 25,557 tons in May, 1869, and 24,221 tons in May, 1868. In the five months ending May 31 this year, the reports reached an aggregate of 437,235 tons, as against 320,745 tons in the corresponding period of 1869, and 233,769 tons in the corresponding period of 1868. A large increase is thus shown in the exports to Russia, while an appreciable increase is also shown in the quantities sent to the United States. The exports have also increased to Prussia, Holland, Spain, the Danubian Principalities, Cuba, Brazil, Chili, British India, etc. ; but they have decreased to Sweden, France, Egypt, Peru, British America, and Australia. The value of the railway iron exported in May was £1,050,154 against £697,022 in May, 1869, and £433,246 in May, 1868 ; and for the five months ending May 31 this year £3,521,561, against £2,480,594 in the corresponding period of 1869, and £1,809,030 in the corresponding period of 1868.

An exchange paper gives the following as the latest measurement of the North American lakes : The greatest length of Lake Superior is 335 miles ; its greatest breadth is 160 miles ; mean depth, 688 ft. ; elevation, 627 ft. ; area, 82,000 square miles. The greatest length of Lake Michigan is 390 miles ; its greatest breadth, 108 miles ; mean depth, 900 ft. ; elevation, 506 ft. ; area, 23,000 sq. miles. The greatest length of Lake Huron is 200 miles ; its greatest breadth is 160 miles ; mean depth, 600 ft. ; elevation, 274 ft.; area, 20,000 sq. miles. The greatest length of Lake Erie is 250 miles; its greatest breadth is 80 miles ; mean depth, 84 ft. ; elevation, 555 ft. ; area, 6,000 sq. miles. The greatest length of Lake Ontario is 180 miles ; its greatest breadth is 65 miles ; mean depth, 500 ft.; elevation, 260 ft.; area, 6,000 sq. miles. The length of all 5 is 1,584 miles, covering an area of upwards of 90,000 miles.

LATE EXPERIMENTS ON HEATON STEEL.

Translation from "Der Berggeist," through "Zeitshrift für Berg und Hütten Wesen."

In his account of the Heaton process, published in 1869, Gruner stated that 0.002 @ 0.003 of phosphorus does not hinder the working of hot steel, and that it increases the resistance of cold steel to tensile force. But its brittleness is increased, so that it is more sensitive to blows and shocks ; the presence of phosphorus being attended by a corresponding want of temper or fibre.

Fairbairn has since obtained more favorable results at Manchester ; but these are found upon critical examination not to disprove, but rather to confirm the statements of Gruner.

At the 39th session of the British Association for the Advancement of Science, Fairbairn presented the results of his numerous experiments, giving at the same time a sketch of the Heaton process, illustrated by a drawing of the apparatus.

He had subjected 6 bars of steel of the Langley mill manufacture to the tests of bending, tension, and compression, and obtained results which seemed to show the superiority of Heaton steel over Sheffield steel.

We give an abstract of the results of these experiments:

Heaton steel shows a superiority to other kinds in resistance to deflection in a ratio of 1.3 : 1.

The active elastic resistance is $1\frac{3}{4}$ times as great as the average of other steels ; so that it is specially fitted to resist impact and extraordinary pressure.

The flexibility and the coefficient of elasticity of this steel are small, being a little below the average value. The mean breaking-load of the 6 bars is larger than the general average ; and as the bars lengthen considerably, we infer a greater active resistance to fracture. The resistance to compression is the same as with ordinary steel.

Fairbairn predicts an important future for Heaton steel ; particularly as it can be made from pig-iron of inferior sort.

As these experiments with Heaton steel did not agree with results which Gruner had derived from the experiments of Kirkaldy (with steel from the iron of Longwy and Hayange), he resolved to find the proportion of phosphorus in the rods employed by Fairbairn. The pig-iron, bright gray and a little graphitic, from which the steel was made contained—

Silicon	0.0210
Phosphorus	0.0106
Sulphur	0.0019

and was refined in Heaton's converter with 12.4 per cent. Chili saltpetre and 1.2 per cent. quartz sand.

According to Gruner's earlier experiments the quantity of saltpetre applied seemed to be insufficient ; and it was supposed that the product of refining still contained foreign substances.

The analysis of the six bars gave—

	1.	2.	3.	4.	5.	6.
Carbon	0.0049	0.0057	0.0052	0.0054	0.0054	0.0047
Silicon	0.0010	0.0012	0.0016	0.0010	0.0012	0.0009
Phosphorus	0.0030	0.0023	0.0024	0.0024	0.0028	0.0023
Sulphur	No trace	0.0001	0.0001	0.0001	Very slight trace.	No trace.

It is seen that the bars have nearly the same proportions of these elements, as might be inferred from their common origin. They are not very hard ; are easily filed, containing 0.005 @ 0.006 of carbon, but at the same time 0.0023 @ 0.0030 of phosphorus.

It would then seem to follow, if Fairbairn's results were correct, that 0.002 @ 0.003 per cent. of phosphorus improves steel, especially by increasing elasticity and resistance. This might hold for these functions of cohesive strength, and yet it would not follow that the same steel bars could also resist the vibratory effects of impact. It may be easily inferred from Fairbairn's results that these tests show the same defects in the steel as were found

in the experiments of Kirkaldy. The bars gave evidence of brittleness and want of temper, and seemed not in condition to resist the molecular disturbances of shocks and blows.

Again it must be remarked that the maximum of elastic extension, which is calculated from experiments in deflection, must necessarily be less than the tearing weight which is applied in direct experiments in tension. But it must be remembered that a rod often parts before the whole load is hung upon it; the effect of a slight disturbance or a shock. The cause lies in the nature of steel, depending on a certain brittleness and shortness of grain.

In the earlier experiments of Fairbairn with English steels (1867), such a condition was shown with very hard steel:

A steel No. 1,	broke at 37.96 tons,	its elastic limit being	30.53 tons.
" " " 37,	" 39.75 "	" "	39.08 "
" " " 39,	" 38.02 "	" "	35.02 "

The same tests gave for—

No. 1,	contraction, 0.00;	elastic extension, 0.006;	permanent extension, 0.0025 tons.
" 37,	" 0.02;	" " 0.0106;	" " 0.0106 "
" 39,	" 0.01;	" " 0.002;	" " 0.0012 "

On the other hand soft steel often gives

Contraction	0.50
Elastic extension	0.10 @ 0.15
Permanent extension	0.15 @ 0.20

The experiments with 6 bars of Heaton steel gave the following results. Two bars parted before the load reached the maximum corresponding to the limit of elasticity:

No. 2 at 41.70	instead of 47.27	tons.
" 4 " 46.82	" 48.56	"

Brittleness was shown in the fact that 4 bars parted without contraction, very suddenly, though the suffered an extension of 0.031 to 0.094. Hence brittleness depends not upon the degree of hardness, but upon a lack of flexibility or fibre.

Softness of steel is shown not only by small percentage of carbon and ease of filing, but also by the extension caused by lateral compression. This amounts to 0.247 @ 0.333 to the square inch for 100 tons, while the hard kinds of steel show a compression of not more than 0.15 @ 0.24.

Hence steel containing phosphorus is brittle without being hard.

Another property of this product is its stiffness and great elasticity. Referring all depressions to the limits of elasticity and the transverse resistance of 1 English square inch, the 6 bars of Heaton steel give values which lie between 1.01 and 1.88 inch. The mean of the other bars is 1.30 @ 1.50 in., and in 3 cases out of 45 the depression exceeds 1.60 in.

It is therefore to be inferred that increased service can be had only for permanent loads, not for those which are sudden and variable.

Gruner sums up in the three following statements:

(1.) Phosphorus in the proportion of 0.002 @ 0.003 makes steel stiff and elastic, increases its elastic tensile resistance and its breaking resistance, without altering its hardness. But this steel, even if but little carbonized, lacks in temper and is short-fibred and brittle.

(2.) To discover the injurious properties it is necessary to apply, not only tensile and transverse loads, but also impact and blows.

(3.) Fairbairn's experiments do not warrant us in condemning the Heaton process finally; for, as was the case in the experiments with Lothring iron, the proportion of saltpetre to silicon was too small.

In conclusion we give the Heaton process as prescribed by Gruner:

(1.) Removing the phosphoric earths from pig-iron by blast and putting into the refining fire.

(2.) Refining the pig-iron and greatest possible diminution of the silicon.

(3.) Drawing from the refining fire directly into the Heaton converter upon a sufficient quantity of saltpetre.

(4.) Working of the blooms in a Siemens-Martin furnace.

Now that the high-level bridge scheme is abandoned, it is expected that a strong effort will be made in the coming session of the British Parliament to obtain the necessary powers for a tunnel under the Severn at New Passage.

STEAM ON COMMON ROADS.

From "The Engineer."

What is the true reason that we nowhere see the steam-engine used to any great extent for common road traffic? There is probably no problem in the whole range of practical mechanics, and there is certainly no other problem in steam engineering which has taxed ingenuity so long, so much, and yet with such comparatively slight results. Almost innumerable inventors, dating from Cugnot, have been trying their hands at it for more than a century. It is true that their work has not been without some fruition. Steam traction engines now carry themselves and their ploughing tackle in farm operations; they are used for drawing heavy loads for short distances on special bits of road; but that is nearly all. Road engines have never yet found general application in England; and, after many different trials at various times, they have almost completely failed in France, in Germany, and America. The multiplicity of the proposals and attempts in this direction is remarkable. We have Savery, and later, Dr. Robinson, ten years before Cugnot's trial, proposing the thing. Then Oliver Evans; in 1784 Watt patented the application of his engine to the purpose; William Symington tried it; and afterwards Murdoch. Oliver Evans actually propelled an engine of some size. The most ingenious attempts were mady by Trevithick; and, after him by Gurney, Gordon, Ogle, Dr. Church, and Dietz in France. The curious, and perhaps significant, point about the history of these attempts is that the principal ones were renewed with an interval of a generation between each. Thus, after the first schemes in 1759–69, we find Trevithick working in 1802–4: Gordon, Church, and many more in 1832–6; and, lastly, Boydell, Aveling, and others, from 1855--65. We have now another ingenious plan, but in spite of all that we have lately heard from Edinburgh about Mr. Thompson's road steamers, we are not inclined—while we wish him every success—yet to make an exception in his favor. In the first place, they have not worked long enough; and, in the second, we do not know the proportion that the excellent roads in and about Edinburgh have contributed to his success. In fact, isolated cases of the partial success of steam power on common roads can generally be traced to the good state of the roads in the given locality.

Trevithick, the greatest genius amongst traction engine inventors, seems at first to have even believed that "railroads are useful for speed and for the sake of safety, but not otherwise; every purpose would be answered by steam on common roads which can be applied to every purpose a horse can effect." In this there is, of course, an evident fallacy. The only reason that greater speed is obtainable on a pair of rails, with a locomotive and its train, than if the locomotive and train were put on a road without rails, is that the rail offers a hard, smooth, unyielding surface, and that the ordinary road offers a soft, rough, and yielding surface. If we took an ordinary train of a locomotive and carriages, turned the flanges off the tires, and placed them on an iron road, made with one smooth level surface—one long metallic table, in fact—we could evidently get the same speed on such a road—which we may suppose perfectly straight and sufficiently wide to get over the difficulty of our want of flanges—as on a nordinary line of railway. As soon, therefore, as a locomotive and train were got to run on rails, it might have been seen clearly that the locomotive steam-engine did not want improving, but that, in order to put steam power on roads, it was the roads that wanted improving. In fact, only a year or so after his patent for 1802, Trevithick came to the conclusion that steam carriages could not be placed on common roads before common roads were radically improved and rendered able to bear heavy loads without giving way and increasing the draught to an impracticable amount. Some of the more able later inventors of traction engines saw this, more or less clearly, and attempted to make the engine carry its own railway, though we are not aware that even Boydell's traction engine and endless railway are now anywhere in practical use. After making the most successful road traction engine of any, we now see Messrs. Aveling and Porter taking the

lead in the production of steam road rollers.

Briefly, the whole future of the application of steam to common roads clearly lies in the improvement, not of the engine, but of the road. In the same way as rails must be laid down before running the locomotive, so must common roads be rendered able to bear heavy weights, and have given them a hard level surface, one approaching as nearly as possible that of the rail table. The nearer this condition of hardness is approached, the more extended will be the use of steam on common roads.

These premises being granted, the solution of the old problem of applying steam to common roads is simply to be found in the general use of the steam road roller. The steam roller must precede the steam traction engine. Experience shows that this process of road-making and maintenance gives us a hard level surface, not liable to sink and take ruts under the wheels, and affording more than sufficient adhesion for propulsion with smooth wheels. The possibility of applying steam in this way would give us what might be termed a universal tram-road, rendering available for steam power our 200,000 miles of macadamized roads. Much in this sense was a passage in a late public speech of such an experienced engineer as Sir Joseph Whitworth, in which he pointed to the improvement of common roads, rather than an extension of tramways. The roads are there, and their improvement by the process, instead of involving an outlay of capital, actually greatly reduces the cost of their maintenance. In our especial case the employment of an engine on common roads, able to move about with facility, also means the application of steam to the conveyance of stone from the various deposits along the road ; to breaking it up and taking it to the required spots before rolling it down. Of extraordinary value would these applications of steam be in countries with such dear labor as that of America.

FLEXIBLE TUBE ENGINE.

From "The Revue Industrielle."

This remarkable machine, working either by aid of a vacuum or of compressed air, was designed and constructed by M. Eugene Bourdon, a skilful French mechanician.

The originality of the principle, and the perfection of the execution of this new machine, appear to us to merit the attention of engineers, and we are glad to be able to present to our readers the above design, which we owe to the kindness of the inventor. The "Revue Industrielle" having specially for its aim the setting forth of new mechanical combinations and industrial progress of all kinds, we shall have occasion often to speak of the productions of M. Bourdon, for he is one of the few engineers who have created machines, and who have known how to employ the more important physical properties of matter.

The cylinder, as may be seen, has been replaced by a flexible tube of brass or steel having an elliptical section.

The piston has been omitted, as also have been connecting rods, stuffing boxes, and slides.

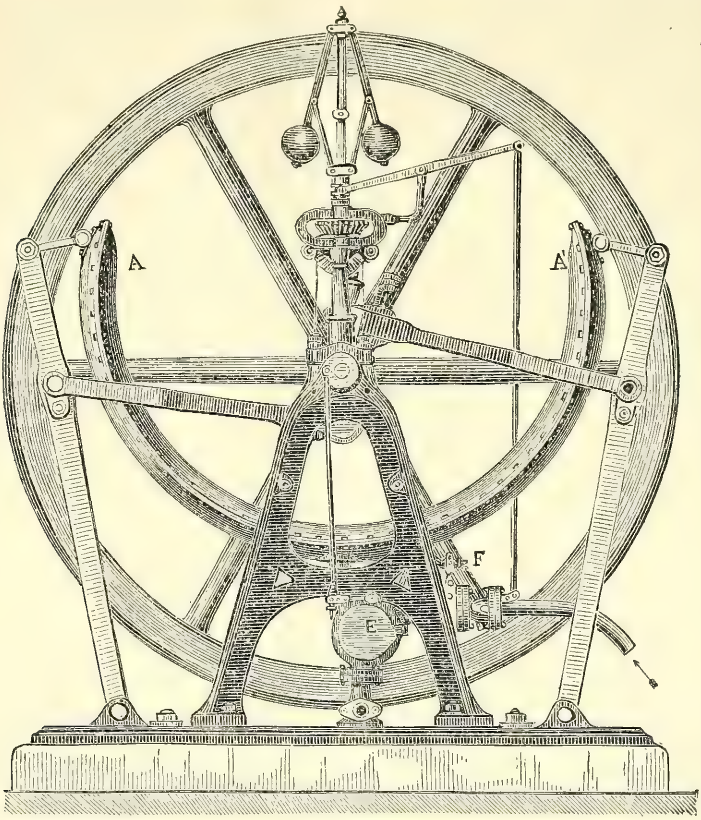
The principal organ exhibits a strong likeness to the manometer tubes of the same inventors; and it is for the reason that this latter instrument has served its purpose so well for so many years that this new application of the same feature affords good promise of success.

The extremities of the crescent A A′ are alternately forced towards or away from each other by the introduction of compressed air into the tube. This back and forward movement is transmitted to the central shaft by means of the levers and cranks as shown in the figure. There is a slide valve at E, and a throttle valve at F, worked by a governor.

In some cases the governor is omitted, for the purpose solely of simplifying the construction ; M. Bourdon considers it inexpedient to omit it in the general use of the engine, as the vibrations would become too rapid and the tube would deteriorate.

In order to compress or rarefy the air the inventor employs the water from the public service pipes; this supersedes the necessity of use of combustibles. This is

a favorable circumstance when simplicity of working and healthfulness are regarded, but quite unfavorable from an economical point of view.



We want several elements to be able to establish a theory for the flexible tube machine. The inventor claims that its useful effect ought to be considerable as a consequence of the elimination of the friction of the piston and connecting rod. It seems to us that it may be claimed that this new machine is too complex. Be that as it may, it works well, and that is the important fact which we wish to record now.

The chief advantage of the absence of a piston is not a diminution of friction, but the avoidance of possibility of leakage, and we believe that in the use of steam this arrangement would be preferable to most rotary engines. So, for example, in a shop where there were twenty machines and a single boiler, by using oil as a combustible the expense of consumption for each machine would be very small, considering the low price of the fuel, whatever may be the reduction of useful effect of the tube.

We shall recur to this interesting subject when we have the results of experiments to communicate to our readers.

M. E. Becquerel says: "The electrical effects produced by the contact of non-oxidizable metals and distilled water (chemically pure) are due, not to any special action of contact, but to the reaction of the water upon the gases condensed on the surface of these metals. The effects vary according to the molecular state of the metals and their temperature. As regards, however, the oxidizable metals, the electrical effects produced by heating them are due to the very slight layer of oxide adhering to their surface, whereby they are rendered positive toward the unpreserved metallic surface."

ELECTRO-HEATING.

By W. LEIGH BURTON, Richmond, Va.

It is well known that much time and money have been spent in experimenting with electricity with the view of utilizing it for various purposes, but it is probable that the idea of obtaining from it a motor has received the largest share of attention. However ingenious some of these contrivances may have been, it has been found that the cost of electricity to be thus utilized was so enormous, that on the score of economy, most, if not all of them have been abandoned, and finally found their way to the receptacles for the curiosities of science. The experiments of Prof. Page in this direction are still fresh in the recollection of the scientific mind; but, with his well-known knowledge of the law of equivalents, it seems strange that, depending upon the source he did for his electricity, he could not have foreseen the failure of his electric-motor. It is said, in fact, that upon the occasion of a public exhibition of this invention in Washington, it ran only a few yards and suddenly came to a full stop. All the coaxing in the world could not prevail on it to move another inch; but when an examination of the battery was made, it was found to be entirely exhausted; or, in other words, so much zinc, platinum and sulphuric acid had been consumed, that in point of economy it would have been cheaper to have burned wood or coal in the furnace of a steam-engine.

The same difficulties would be in the way of utilizing electricity as a heating agent provided a chemical battery had to be relied upon; for even if a current is sent through a small wire so as to evolve any considerable amount of heat, the battery is rapidly exhausted. With a knowledge of these facts, then, it would be hopeless to expect any satisfactory results by the employment of chemical electricity for heating purposes; but fortunately there is another kind that can be made available, as it has been demonstrated by actual experiment that a properly organized magneto-electric machine furnishes a current admirably adapted for this purpose; and moreover, what is of great importance, it is uniform as long as the instrument is operated at the same rate of speed.

Electricians are aware of the fact that by a modification of the *helices*, magneto-electric machines may be made to produce a current of either *quantity* or *intensity*; that from the former possessing great heating power and producing scarcely any shock, while that from the latter has very little heating power; but the shock from a powerful instrument would be fatal to animal life.

But it is with the *quantity* current that the writer has to deal, and he proposes to show how it may be made available for heating purposes; but before doing so a description of the "electro-heating apparatus" will be necessary.

The main feature of the invention is, that it consists of a chain or coil made up of alternate obstructions and free conductors. It is based upon the fact that electricity, in passing through a conductor of insufficient capacity (such for instance as a small wire) develops heat. If, however, the attempt is made to heat any considerable length of wire it will be melted, for the reason that heat increases the non-conductivity of it, or, in other words, increases the resistance. Now, by this arrangement of alternate obstructions and free conductors, it has been found that a powerful current of electricity may be sent through *any length* of the chain, and the result is, that though the tendency of the current may be to produce incandescence in the obstructing intervals, the heat is so rapidly taken up by the larger pieces of metal or radiators, that this is prevented entirely. In the experiments of the writer he has employed for the obstructing intervals, platinum wire one-hundredth of an inch diameter, and for the radiators, pieces of copper of about one-eighth of an inch. These radiators also perform the part of reservoirs so as to produce an equal distribution of the current; and hence when a sufficiently powerful current is sent through any length of the chain, the same caloric effects are produced in every portion of it, which fact has been fully demonstrated by actual experiments with the Wilde magneto-electric machine, in charge of the Engineer Bureau in Washington.

Now, it is simply by arranging this

chain in a compact form that sufficient heat may be accumulated for practical purposes.

For the purpose of heating railway cars it is proposed to place a heater, in the form of a metallic plate, in front of each seat so that the feet of passengers may rest on them ; and it is supposed that the heat radiated from 25 or 30 of these plates would, by heating the lower strata of air (which is never accomplished by stoves), produce in the body of the car a comfortable temperature.

Admitting, then, for the present, that the principles upon which this invention is based are sound, and also, if a current of electricity is furnished these results will be produced, the next inquiry would be as to the source from which the electricity is to be obtained. This inquiry can be answered by stating that in applying the invention to cars, it is proposed to employ a magneto-electric machine, placed under the car, and obtain the power to operate it from the axle.

In the face of a statement of a so-called "expert" to the effect that the current from a magnet machine possessed no heating power whatever, the instrument which has been referred to in another place, will heat to redness over 20 ft. of No. 20 iron wire ; and, in fact, it is estimated that it possesses a heating power equal to *ten times* that of the enormous battery in the Capitol building in Washington, which is composed of 164 cells, as large as an ordinary wooden bucket.

The heating power of magneto-electric machines being established and admitted, the next inquiry would be as to the economical application of them. "What is the cost of them, and what power is necessary to operate them?" some one is supposed to have inquired.

By means of another invention of the writer's, which he has termed a "circuit-changer," very large machines may be dispensed with entirely ; and of course the smaller the machine the less it would cost and the less power it would require to operate it. This instrument consists of a revolving shaft or barrel, one end of which is kept in constant connection with the battery or machine, by means of a brake. Placed on the shaft are a number of points arranged spirally, so that in revolving the instrument no two points approach the same line at the same time. Corresponding to these points are springs, and when the apparatus is in operation each point is brought consecutively in contact with corresponding springs. To give a better idea of the contrivance, it might be compared to a musical box, the difference being that in revolving it a *contact* is made instead of a musical sound. By means of this instrument a current of electricity may be sent consecutively through as many different circuits as there are points on the cylinder, the only limit being the number of the latter that can be placed on a cylinder of a certain length and diameter. It is easy to understand, therefore, if a current of electricity of a certain power will produce certain calorific effects by being sent through a certain circuit at the rate of, say 500 times in a minute, it would produce the same effects by being sent through any other, or 100 more, for the reason that the same current is sent through each different circuit the same number of times per minute ; and but for the wear which it would necessarily entail on the instrument, it could be revolved with such rapidity as to make it in each very nearly continuous.

In order to warm a railway car, then, it would require a circuit-changer with points on it corresponding to the number of seats ; and if a passenger should find the heat under his feet uncomfortable, he could easily, by a contrivance for the purpose, cut off the current, and at once cause an abatement of it.

The writer does not pretend to assert that this method of producing heat is actually cheaper than the combustion of wood or coal in stoves ; but in its application to cars he contends that it would certainly be safe ; for in case of a train being thrown from the track, instead of being roasted alive by a red hot stove, a passenger, escaping the perils of the wreck, might escape with his life. But the whole question of its economical application, however, is simply narrowed down to what power it would require of the axle of a car to operate a magneto-electric machine, and what, if any, additional fuel it would require to be burned in the locomotive to compensate for it. There might be differences of opinion on this point, but practical railroad men assert it frequently happens that, by some carelessness of the brakesman, more resistance to the progress of the train is

created by not raising the brakes of some particular car, than would be produced by operating a sufficient number of machines to warm an entire train. As bearing on this point also, Prof. Bartlett, of West Point, says:

"It is very certain that of two cars in all other things equal, one having your apparatus and the other not, that the latter must run the faster, and just by the difference of velocity due to the power necessary to give motion to your magnets.

"But you need not give yourself any troubles in this direction. There will always be power enough in a properly constructed locomotive to give sufficient speed to a train and turn your apparatus also."

Mr. M. F. Maury, Jr., also says, in substantiation of these views:

"The power of a loaded passenger car running at express speed is 7 H. P. A £90 magneto-electric machine takes 1 H. P. to work it. Therefore, in applying your invention to heating cars, you can, as you propose, easily derive the working power from the axle of the car."

But it is not only in railroad cars that electro-heating may be advantageously used; in factories, machine shops, or wherever a cheap motive power exists, it may be employed to great advantage.

MINERAL RESOURCES OF RUSSIAN TURKESTAN.

From "The Engineer."

The annexed observations upon the mineral resources of the newly acquired Russian territories in Central Asia are extracted from a recently published work, "Pashino's Turkestan in the Year 1866." The author visited the newly-occupied territory in an official capacity shortly after the capture of Tashkend, but the compilation of his work was deferred through a variety of circumstances until the close of the year 1868; his observations professedly embrace the result of the explorations which had been made up to the latter date, and consequently are more recent than those contained in other works which have appeared in an English or German dress.

M. Pashino remarks that "the Russian Government has entertained great expectations of the wealth of its new possessions, and it can only be hoped that its anticipations may not be disappointed. Later and more minute inquiries respecting the mineral resources of the country, and the prospects of finding gold there have not tended to confirm the reports of earlier writers." The evidence, however, is only negative; and, bearing in mind the undeveloped condition of most of our own colonies, it would appear unfair to attach overmuch weight to these avowedly incomplete investigations.

He gives a summary of the latest inquiries up to the date of his work as follows:—

Colonel Tartarounoff, of the Topographical Engineers, who was specially deputed to examine into and report upon the probable supply of coal, discovered a bed of that mineral 9 ft. in thickness on the banks of the river Bogon, but situated at such a depth below the surface as to render its profitable working very problematical. Another bed, not as yet explored, has been found on the banks of the Karatchak, ten versts from Turkestana, and thirty versts from the Syr Daria.

A rich lead vein was discovered by a certain M. P——on the banks of the Tourlan-Azi, on the road from Turkestana to Tchoulak-Kurgan. Also a bed of steam coal near Yesendi-Boulak.

Of the coal nothing is known; but the lead, it would seem, is worth working. The vein yields 76 per cent. of ore, with 5 lbs. to 6 lbs. of silver in each pood (40 lbs.) of lead.

Explorations in search of gold were made by the late M. Koleben, of the Topographical Engineers, by M. Perveshon, by a wealthy native gentleman residing in Tashkend, Said Azim, and by others. No traces of gold were discovered by the two explorers first named. According to the reports of some of the others it was observed in ten places on the banks of the Tchourtchouk, and Tchatkali, the latter being a small mountain stream distant about seventy versts from Tashkend, and of which the first-named stream is the prolongation.

M. Pashino observes that it is very difficult to ascertain the extent of the re-

sources of the country in this respect, inasmuch as the auriferous strata are overlaid by a bed of peat, in some places of nine to twelve sajens (60 ft. to 80 ft.) in thickness. The obstacles in the way of "prospecting" were, he thinks, the cause of the failure of the explorations made by the Topographical Engineers. At the same time he is disposed to believe that the alluring reports of the wealth of the gold deposits along the banks of the Syr Daria, which were published abroad long since, may have originated in part in the vain-glorious garrulity of Asiatics desirous of exaggerating the wealth of their native land.

"It is reported," he says, "that immediately previous to the Russian occupation of the country gold dust was sold secretly in the bazaar at Tashkend for seven roubles the zolotneek, but that since it has been smuggled from Russia the price has fallen to four roubles. This appears probable. Places have been found beneath the peat, excavated to a depth of one or two sajens, from whence, according to the natives, the dust was extracted without the cognizance of their rulers. By these accounts the dust was sifted in horse-hair bags, and disposed of privately in the nearest bazaar. Other reports fully confirm the belief that gold was thus found, and that the chief impediment now lies in digging for it." It would seem that the practice has been discontinued since the advent of the Russians; but the anticipated profits have induced the Russian Government to take prospective measures for imposing a tax on such operations.

Of the amount of silver found in the country M. Pashino has no information. It is the most extensively used of the precious metals, being employed for various articles of women's attire, necklaces, bracelets, earrings, studs, etc., for horse-furniture, buckles, breast-plates, and the like, and for ornaments to scabbards, sword belts, etc.

Turkestan is rich in indications of iron, such as are usually found in the vicinity of the coal measures.

The iron used for manufacturing purposes is imported *viâ* the Steppes, from Russia or from Persia. Thanks to the judicious policy of the Asiatic Governments, who have allowed the importation of metals duty free, it sells after its long journey, at 5 to 6 roubles per pood; that is to say, exclusive of carriage, at 3.50 to 4 roubles per 40 lbs. weight. Much of the iron brought from Russia is imported in a manufactured state.

Copper occurs in the neighborhood of the river Kelessy. Indications of its existence are also found at certain points on the left bank of the river (Syr Daria). Gems and precious stones are sold in the bazaars, but rarely and in small quantities. In all cases they appear to be of foreign importation. Amethysts, rubies and turquoises are brought from Persia; corals and small pearls from India; rock crystal, carnelians, and jasper from Siberia.

M. Pashino states that the natives are by no means behindhand in a desire to discover hidden wealth, but he insinuates that their efforts are usually restricted to the quest of real or imaginary hoards.

Considerable deposits of rock salt are reported by a M. Fedoroff to exist on Mount Kazi-Kurt, about forty versts from Tchemkend. Salt is also obtained by evaporation from several of the lakes, and beds of the mineral are said to occur on the hills between Pishpeck and Tokmack.

The Leclanché cell, which is largely used in the batteries of the French telegraphic system, is thus reported on by Professor Morse: "This battery consists of a prism of carbon for its positive pole, which is surrounded by a mixture of peroxide of manganese and carbon pulverized, filling the porous jar. This jar is put into the glass jar containing a solution of sal-ammoniac; within the same glass jar and solution is a prism of amalgamated zinc, forming the negative pole. Its action is thus: On closing the circuit the sal-ammoniac is decomposed, the chlorine of the solution is absorbed by the zinc, the negative pole; while the hydrogen and the ammonia pass to the positive pole, reducing the peroxide of manganese. According to the inventor's explanation, 'the peroxide of manganese mixed with carbon being a good conductor of electricity, the system may be considered as a single fluid element, in which the positive pole is formed of an artificial metal having a great affinity for hydrogen.'"

The copperplates of Audubon's "Birds of America" are for sale in this city.

ON THE NATURAL LAWS OF MUSCULAR EXERTION.

By W. STANLEY JEVONS.

From "Nature."

Among a multitude of profound and happy suggestions to be found in Mr. Babbage's "Economy of Manufacture," are some remarks on the relation between fatigue and the rapidity or degree of muscular exertion. Coulomb, it appears, had previously investigated the most favorable load for a porter, and had ascertained by experiment that a man walking upstairs without any load, and raising his burden by means of his own weight in descending, could do as much work in one day as 4 men employed in the ordinary way with the most favorable load. Mr. Babbage clearly points out (p. 30) that the exertion necessary to accomplish any kind of work consists partly of that necessary to move a limb of the body, and partly of the force actuallyutilized in the work. The heavier the work done, the larger the proportion, therefore, of the power utilized. But there is a limit to this mode of increasing the useful effect, because, by the natural constitution of the muscles, they can only develop a limited amount of force in a given time, and the fatigue rapidly increases with the intensity and rapidity of exertion. Hence there is in every kind of work a point of maximum efficiency, which is in practice ascertained more or less exactly by frequent trial.

This subject appeared to me to possess interest for at least two reasons : it might be made to throw some light upon the chemical and physiological conditions of muscular force ; it might also point out how we could make some commencement, however humble, of defining the mathematical relations upon which the science of economy is founded. I have therefore attempted to add precision and certainty to the ideas put forth by Coulomb and Babbage, by some experiments of a simple kind.

The first and least interesting series of experiments consisted in ascertaining the comparative distances to which various weights could be thrown upon level ground. The product of the weight and distance was taken as the measure of useful work, and it was the object to ascertain according to what law this varied, and at what point it was a maximum. The weights employed varied from $\frac{1}{2}$ lb. up to 56 lbs., and were thrown as nearly as possible in a uniform manner and at the most advantageous angle. About 57 experiments at different times were made with each weight, or 456 experiments in all ; and it was quite obvious that good average results were obtained, the correspondence of different sets being very satisfactory. The results are as below :

Weight in lbs.	Average distance thrown in ft.
56	1.84
28	3.70
14	6.86
7	10.56
4	14.61
2	18.65
1	23.50
½	27.15

A little consideration showed it to be probable that these numbers would agree with an equation of the form—

$$x = \frac{p}{w + q}$$

in which $x =$ distance thrown,
$w =$ weight thrown,
$q =$ constant weight representing about half that of the arm,
$p =$ constant amount of force exerted.

The experiments give us eight distinct equations by which to determine the two unknown quantities p and q ; and by the method of least squares we determine their most probable values to be—

$$p = 115.7$$
$$q = 3.9$$

The formula thus becomes—

$$x = \frac{115.7}{w + 3.9}$$

And calculating thence the distances for the several weights, they are :—

Weights.	Calculated distances.	Difference from experiment.
56	1.93	+.09
28	3.63	−.07
14	6.46	−.40
7	10.61	+.05
4	14.65	+.04
2	19.61	+.96
1	23.61	+.56
½	26.30	−.85

The correspondence is so close as to show that the formula is in all probability the true one, and the quantity 3.9 does not differ much from half the weight of

the arm, which might be expected to enter into the question. The fact is that the correspondence is embarrassingly close, and I am inclined to attribute it partly to chance. The experiments could hardly have been expected to give results accurate to an inch or two in some cases, and though the formula must be considered true on the ground of experiment, I do not quite see how to explain it on mechanical principles.

If we regard the useful effect as the moving of the greatest amount of matter, it is $x \times w$, and, theoretically speaking, increases continually with w. For the different weights and calculated distances, it is as follows :—

Weight.	Useful effect.
56	108.1
28	101.6
14	90.4
7	74.3
4	58.6
2	39.2
1	23.6
½	13.2

But in reality it was not possible to raise the larger weights without exerting additional force unconsidered in the formula, so that the practical maximum of efficiency is probably about 28 lbs., in the case of my own right arm. With different people it would, of course, vary somewhat.

The above experiments completely confirmed Mr. Babbage's remarks, but did not seem to lead to any further results. I proceeded, therefore, to other experiments upon the rate of exhaustion of muscular fibre. One mode of trial was to raise and lower various weights by a pulley and cord through the convenient range of the arm, continuing the motion with unrelaxed rapidity until the power of the muscles was entirely exhausted. The results of more than fifty experiments were as follows :—

Weight lifted.	Average number of times.	Useful effect.
56	5.7	319
42	11.9	500
28	23.0	644
21	37.6	790
14	110.0	1554

These numbers show that the total greatest amount of labor can be done with small rather than large wheels in this case ; but they fail to give any regular law, owing probably to the weight of the body being brought into use with the larger weights.

The mode ultimately adopted was to hold out various weights in the hand at the full stretch of the arm, and to observe the times during which they could be supported. No two experiments were made with the same arm, without allowing, at least, one hour to elapse, so that the vigor of the muscles might be restored. With the smaller weights there was naturally some uncertainty as to the time, but in the case of the large ones the time was very definite. Altogether 238 experiments were made, an equal number with each arm. Uniting all the experiments for the same weight, the results are :—

Weight.	Times in seconds.
18	14.8
14	32.5
10	60.3
7	87.4
4	147.9
2	218.9
1	321.2

These results are pretty satisfactory averages ; thus the probable error, for two cases indifferently chosen, was, for 18 lbs. in the left hand about .5, and for 4 lbs. in the right 2.7, and the error of the combined results would be less. With the exception of the results for 10 lbs. in the left arm, which appear to be somewhat in excess, these numbers are very regular, and point to a systematic law governing the rate of fatigue. The useful effect, or the product of the weight and time, shows a decided maximum, about 7 lbs., as follows :—

Weight.	Useful effect.
18	266
14	455
10	603
7	612
4	592
2	438
1	321

If the weight held be very small, much power is lost in merely sustaining the arm ; if the weight is large, there is comparatively little loss on that account, but the power of the muscles is soon run out, and no sufficient opportunity for restoration is allowed. The weights chosen for dumb-bells and other gymnastic exercises appear to be about those which give the maximum efficiency.

I have made several attempts to explain these numbers by reasonable suppositions as to the conditions of exhaustion and restoration of muscular power. It seemed reasonable to suppose that the supply of

new matter from the blood would increase in some proportion to the vacancy or want of it, but all such conditions led to integrals of a logarithmic form, which could not be easily compared with experimental results. No formula that I obtained could be made to agree properly with the figures, and all that can be said is that the curve representing the results has a certain appearance of a logarithmic character, so far agreeing with the formulas obtained. Those who are acquainted with the physiology of the subject might succeed better; I am not sure, for instance, how far the failure of strength is due to the exhaustion of the original substance of the muscle, how far to the inadequacy of the current supply of blood. It is a question again how far in any case of muscular action the supply is promoted by the increased action of the heart, or checked by the possible constriction of the arteries. If these questions have not been or cannot be otherwise decided, they might, perhaps, be indirectly solved by experiments of the kind described.

My own object, however, was not to intrude into the domain of physiology, but to show that definiteness might possibly be given by degrees to some of the principles and laws which form the basis of the science of political economy. In some speculations upon the mathematical theory which must underlie that science (read at the British Association in 1862, and published in the Journal of the Statistical Society for June, 1866, p. 282), I endeavored to show that it was only the the excessive difficulty of determining the character of the functions involved, which prevented economy from taking the mathematical form and standing proper to it. There is little doubt as to the principles of the subject; but when we try to put them into figures, the data are found to be so deficient, complicated, variable, and subject to disturbances of all kinds, that any hope of accuracy soon dies away in most cases. In the above experiments I have attempted to determine the exact character of the functions connecting the amount of work done with the intensity and duration of labor in certain simple cases. These cases, however unimportant in themselves, represent principles which have innumerable applications in common life.

THE DECAY OF STONE.

From "Engineering."

The recommendation of Mr. E. M. Barry, the architect of the Houses of Parliament, and of Mr. F. A. Abel, the well-known chemist of the War Department, to attempt the arrest of decay in the stone-work of the Westminster Palace, has just been produced in a report, ordered to be printed by the House of Commons. This recommendation is—oil. To cover the walls of the building, to saturate its tracery, and to soak its sculptured frontage, is the process suggested by these gentlemen. A process ancient and inefficient, one that has long been superseded by other less imperfect though crude methods, which in their turn have given place to the more recent and scientific methods. The fact is that a less satisfactory means of preserving stone could hardly have been proposed, and the wonder is that such men as Messrs. Barry and Abel should have been so short of resources that they could recommend nothing more efficient. Not only would oil be difficult of application, but, perishable as it is, it would quickly change its nature, oxidize, and thicken, until it attracted the floating impurities in the atmosphere, and would only conceal the hastening work of decay. Without advancing to the present time, more suitable remedies might have been offered for consideration; soft soap and alum would have been better, so would wax; while paraffine carefully applied would have answered best of all. But the time is past for prescriptions such as these, and the successful method devised by Mr. F. Ransome affords a rapid and effectual means of successfully preserving the stone, hitherto a thing never accomplished. We have already alluded to this process, and it is known that when it has been used good results have always followed. As is well known, it consists in the successive application of three solutions, the first containing soluble phosphate of lime; the second, baryta; and the third a solu-

tion of silicate of potash, rendered neutral by the late Professor Graham's well-known process of dialysis. These solutions successively applied, combine and form an insoluble and imperishable mineral compound, which effectually resists the action of the atmosphere, and by indurating the stone at once arrests its disintegration. The extensive experience which has been gained by the adoption of this method, places it far beyond the region of experiment, and justifies its recommendation under nearly all circumstances. And there can be no reason why, successful in every case hitherto, it should fail if it were properly applied to the failing stone work at Westminster.

That the Ransome, or some such analogous process will have to be adopted for the preservation of many of our metropolitan public buildings is certain. From a variety of causes independently of that of age, some of our finest structures are yielding to the insidious attacks of impure atmosphere and impure rainfall. The same forces of nature ever at work destroying one combination to gain the material wherewith to rear up another, and which slowly and constantly disintegrate and crumble rocks, blending them indistinguishably with the soil, is fortified by the powerful allies, called into existence by the never-ceasing necessities of the metropolis, and wears out the stones employed in our buildings, with a rapidity dependent upon the class of material upon which the forces act.

Limestone, if containing magnesia, attacked by the sulphurous acid laden atmosphere, effloresces quickly with a soluble sulphate of magnesia. If it hold carbonate of lime only, the same agent rapidly produces soluble crystals of sulphate of lime.

Sandstone again is destroyed because the action of the atmosphere rapidly changes the insoluble calcareous cement which binds the particles together into a soluble form, and the whole material crumbles when its cement is thus destroyed. And while the air charged with the destructive agents is a never-ceasing and perpetual enemy, the impregnated rain water is not only formidable from the same cause, but is formed into a force more actually dangerous because its effects are intensified and localized, as evidenced by the ruin it produces in many public buildings, in places exposed to its concentrated influence. Not only, indeed, does the rain water wash away by degrees the soluble portion of stone changed by the atmosphere, but, containing within itself the elements of destruction, it forms a more active agent which can be resisted only by rendering the stone impervious to its action. And this can only be done by indurating the material so that it may be enabled to set the opposing elements at defiance, which neither oil nor any of the old-fashioned mechanical or chemical appliances of the past are able to effect.

The quantities of materials stated to have been used in the construction of the Thames Embankment, lately opened, are as follows :—Granite, 650,000 cubic ft. ; brickwork, 80,000 cubic yds. ; concrete, 140,000 cubic yds. ; timber (for coffer-dam, etc.), 500,000 cubic ft. ; caissons (for ditto), 2,500 tons ; earth filling, 1,000,000 cubic yds. ; excavation, 144,000 cubic yds. ; York paving, 125,000 superficial ft. ; broken granite, 50,000 superficial yds.

Some French photographers are recommending chloride of aluminium for salting paper, instead of the chlorides of sodium and ammonium generally used at present. The chief advantage of using this salt appears to be that the image is retained well on the surface, and that consequently the details in the shadows of the print are better rendered.

The new iron hydraulic gun carriage invented by Colonel H. Clerk, Royal Artillery, F. R. S., superintendent of the Royal Carriage Department, Royal Arsenal, Woolwich, has been completed and fitted up in the Government marshes at Woolwich for experimental purposes. The gun is specially designed for use in the Royal Navy.

No attempt to build Government offices on the Thames Embankment will be made this year, and before any such attempt is made at any future time Parliament is to have full opportunity to discuss the matter.

ON THE CALCULATION OF EXCAVATION AND EMBANKMENT TABLES FOR THE USE OF RAILROAD ENGINEERS.

By WM. H. GRIFFIN, C. E.

Engineers frequently find themselves, when in the employment of a new company, in want of tables, adapted to such bases and slopes as are not contained in any published tables. The following expeditious and easy method of calculating earth-work tables has been familiar to the writer for more than twenty years, and it is believed is now published for the first time.

As a preliminary to the method, I will take the following equation :

$$y = a\,x^m + b\,x^{m-1} + c\,x^{m-2} + \ldots + p\,x + q,$$

and explain that if we give to x a succession of values, increasing according to an arithmetical progression, the values of y will increase according to a law which is easily ascertained. If we give, in the foregoing equation, to x successively the values 0, 1, 2, 3, 4, etc., we shall ascertain the corresponding values of y. Then, taking the differences of the values of y, we will obtain the first order of differences, generally designated D_1. Then, taking the differences of the differences, we will obtain the second order, designated D_2. And again, by taking the differences of the second order we obtain a third order, and of the third order a fourth, and so on, until an order is finally arrived at that is constant. If m represents the highest exponent of the equation, then the mth order of differences will be constant. An equation of the fifth power giving five orders; one of the fourth power four orders; a cubic equation three orders, and a quadratic equation two orders.

Upon the above principles, let it be required to calculate an excavation table, for a base of twenty feet, with slopes of three-quarters to one, and for one hundred feet lengths. Let y represent the cubical contents in yards, and x the depth of cutting in feet and tenths of feet. Then we shall have this equation:

$$y = \frac{100}{27}\,(20 + \tfrac{3}{4}\,x)\,x = \frac{100}{27}\,(20\,x + \tfrac{3}{4}\,x^2) =$$
$$3.703\,(20\,x + \tfrac{3}{4}\,x^2 = 74.074\,x + 2.777\,x^2.$$

Now give to x a regular succession of values, as 0, 1, 2, 3, etc., and we will have

For $x = 0$, $y = 0.$
For $x = 1$, $y = 76.851,851.$
For $x = 2$, $y = 159.259,259.$
For $x = 3$, $y = 247.222,222.$
For $x = 4$, $y = 340.740,740.$

Take the differences of these values of y and the differences of the differences, and we will have :

D_1	D_2
76.581,851	
	5.555.555.
82.407,407	
	5.555,555.
87.962,962	
	5.555,555.
93.518,518.	

We now rule four columns, designated respectively x, y, D_1 and D_2, and having inserted the figures already ascertained, we will add the figures in column D_2 to the previous ones in column D_1 and then those in column D_1 to the previous ones in column y, and will thus ascertain the value of y, for the corresponding value of x, or the cubical contents, for the particular depth.

x	y	D_1	D_2
0	0		
1	76.851,851,851	76.851.851,851	5 555.555,555
2	159.259,259,259	82.407,407,407	5.555,555,555
3	247.222,222,222	87.962,962,962	
4	340.740.740,740	93.518,518,518	
5	439.814,814,814	99.074,074,074	
6	544.444,444,444	104,629,629,629	
7	654.629,629,629	110.185,185,185	
8	770.370,370,370	115.740,740,740	
9	891.666,666,666	121.296,296,296	
10	1018.518,518,518	126.851,851,851	
11	1150.925,925,925	132.407,407,407	
12	1288.888,888,888	137.962,962,962	
13	1432.407,407,407	143.518,518,518	

In this way we can continue the table to any depth that may be required. If we notice the figures of the decimals in column D_1, we shall see that they are repeated for every ninth foot. This is as it should be, for 5.555 multiplied by 9 is equal to 50,000. Therefore, after the first ten feet, the calculation is proceeded with with much less trouble and difficulty.

To make the calculation by tenths of feet. First find the orders of differences by substituting for x, in the foregoing

equation, the values 0, 0.1, 0.2, 0.3 0.4, and the following results are obtained:

		D_1	D_2
For $x = 0 - y =$	0.		
For $x = 0.1 - y =$	7.435,185	7.435,185	
For $x = 0.2 - y =$	14 925,925	7.490,740	0.055,555
For $x = 0.3 - y =$	22.472.222	7.546,296	0.555,555
For $x = 0 4 - y =$	30.074,074	7.601,851	

Four columns are now again ruled, and we then proceed in the same manner as for whole feet.

a	y	D_1	D_2
0	0		
0.1	7.435,185,185	7.435,185,185	
0.2	14.925,925,925	7.490,740,740	0.055,555,555
0.3	22.472,222,222	7.546,296,296	0.055,555,555
0.4	30.074,074,074	7.601,851,851	
0.5	37.731,481,481	7.657,407,407	
0.6	45.444,444,444	7 712,962,962	
0.7	53.212,962,962	7.768,518,518	
0.8	61.037,037,037	7.824,074,074	
0.9	68.916,666,666	7.879,629,629	
1.0	76,851,851,851	7.935,185,185	
1.1	84.842,592,592	7.990,740,740	
1.2	92.888,888,888	8.046,296,296	
1 3	100.990,740,740	8.101,851,851	
1 4	109.148,148,148	8.157,407,407	
1 5	117.361,111,111	8.212,962,962	
1.6	125.629,629,629	8.268,518,518	
1.7	133.953,703,708	8.324,074,074	
1 8	142.333,333,333	8.379,629,629	
1.9	150.768,518,518	8.435,185,185	
2.0	159.259,259,259	8.490,740,740	

We observe that the decimals again repeat themselves in column D_1, for every ninth foot.

In calculating earth-work tables, after the method here set forth, the calculations should always be made separately, for the whole feet and tenths of feet. The one will be a check on the other, and consequently any error in the figuring will be readily detected.

If one should desire to calculate earth-work, for final estimates, with the same accuracy as by the prismoidal formula, it can be done with the tables calculated as the foregoing, and with much more expedition. It is only necessary to add the cubical contents for each end-depth to four times that for the average depth, and then take one-sixth of the sum, and the same result is obtained as the prismoidal formula would give.

Suppose, for instance, that we should desire to know the amount of excavation for a cutting 100 feet long, and one foot deep at one end and nine feet at the other.

The foregoing table gives:—

For 1 ft.................... 76.853 cu. yards.
For 9 ft.................... 891.666 "
For 5 ft. 439.814 c. yds., which
mutiplied by 4 = ...1759.259 "

Amount...............2727.777 "

One-sixth of which is 454.629 cubic yards; exactly the same result as given by the Prismoidal Formula.

For approximate estimates we can merely average the cubical contents for each end depth, or take the cubical contents for the average depth—the former giving too much and the latter too little.

Take the last amount again.

The Prismoidal Formula gives..454.629 cu. yards.
The average depths give ....439.814 "
The average cubical contents
give.......................484.259 "

The average depth giving 24.814 yards too little, and the average contents 44.444 yards too much.

In order to show that the law of the differences holds good, for cubic equations, as well as for quadrature, I will take the following:

$$y = x^3 + 2x^2 + 3x + 4$$

Now give to x, in succession the several values, 0, 1, 2, 3, etc., and arrange a table as before.

x	y	D_1	D_2	D_3
0	4			
1	10	6		
2	26	16	10	6
3	58	32	16	6
4	112	54	22	
5	194	82	28	
6	310	116	34	
7	466	156	40	
8	668	202	46	
9	922	254	52	
10	1234	312	58	
11	1610	376	64	
12	2056	446	70	
13	2578	522	76	
14	3182	604	82	
15	3874	692	88	

The splendid new steamer Scandinavian, of the Allan line of mail steamers, left Quebec at noon on the 9th July last, and arrived at Liverpool at 6.40 A. M. on the 18th. Thus the time occupied in the run to Liverpool was 8 days, 13 hours, and 55 minutes. This is the quickest passage ever made between Quebec and Liverpool.

THE GREAT TRIGONOMETRICAL SURVEY OF INDIA.

From "The Engineer."

The Indian Survey Department, under the direction of the superintendent of the Great Trigonometrical Survey, and of the Surveyor-General of India, comprises three distinct branches, viz.: the Great Trigonometrical, the Revenue, and the Topographical Surveys, each of which has a separate staff of superintending and executive officers. The operations of the Great Trigonometrical branch of the department are essentially scientific, and of the highest order of geodetic undertakings, and form the basis of the geographical maps of India; its subjects are similar to those of the great national scientific surveys undertaken in other parts of the world for the determination of the figure of the earth and the three co-ordinates of latitude, longitude, and elevation. It is under the more immediate control of a superintendent, whose head-quarters are at Dehra Dhoon, at the foot of the Mussoorie Hills, and is composed of a staff of 24 officers and 46 assistants. This staff is divided at present into 15 parties of varying strength, which are scattered over India, and are employed in trigonometrical, topographical, geodetic, astronomical, and levelling operations, as well as geographical explorations beyond the frontiers of British India. The trigonometrical operations comprise the primary and secondary triangulation, and the measurement of base lines for their verification.

The Revenue Survey branch, in the Bengal Presidency, extends its operations into such parts of the country as are under British administration, and yield a fair revenue. It is the most extensive branch of the department, and to insure proper supervision has been placed under two superintendents, each of whom has a distinct circle of control; the head-quarters of both being at Calcutta. The entire staff consists of two superintendents, 31 military and civil officers, and 73 assistants, with a large addition of subordinate native agency.

The Topographical branch of the Indian Survey Department is under the immediate superintendence of the Surveyor-General of India, whose head-quarters are at Calcutta. The staff consists of 15 military and civil officers, and 49 assistants, with a small number of native surveyors and draughtsmen, divided into 7 parties, employed in various parts of Upper and Central India. The Topographical Survey operates chiefly in hilly and jungle-covered ground, yielding but little revenue in parts of the country not actually under British management, and in friendly native states along the British frontier. Its object is to obtain a cheap, rapid, and reliable first survey for geographical and administrative purposes.

The Trigonometrical Survey, which at the present time extends from Cape Comorin to Thibet, and from the meridian of Calcutta to that of Cashmere, was commenced at the beginning of the present century by the late Colonel Lambton. That officer, who had previously served as a surveyor in America, joined her Majesty's 33d regiment, at Calcutta, in the year 1797. Professor Airy, in his report on Astronomy presented to the British Association in 1832, stated that, at the beginning of the century, an arc was measured "in India by Reuben Burrows." Of this, however, we have been unable to find any confirmation; Mr. Burrows did make many observations of latitudes and longitudes of places in Bengal, which were more accurate than any others previously determined, a list of which was published in the "Asiatic Researches," but no account is to be found of any operations by him for the measurement of an arc of the meridian.

Immediately after the fall of Seringapatam, and the successful termination of the war with Tippoo, Captain Lambton brought forward his plan of a geographical survey of part of the peninsula of India. This work subsequently became the nucleus of the Great Trigonometrical Survey; but the first idea was much more circumscribed, and was confined to throwing a series of triangles across from Madras to the opposite coast, for the purpose of determining the breadth of the peninsula in that latitude, and fixing the latitudes and longitudes of a great many important places, the geography of which was supposed to be very erroneous. This

plan was, in the year 1800, submitted to Government, with the recommendation of the Duke of Wellington, to whose cordial support the Trigonometrical Survey of India owes its origin. Lord Clive was at that time Governor of Madras, and warmly approved of the undertaking, which was accordingly sanctioned by Government. Instruments were forthwith ordered from England, and in the interim a preliminary survey was made of that part of Mysore extending from the Eastern Ghauts to Seringapatam and Perah westerly, and to Baggapilly northerly, taking in some points within the ceded districts. The instruments used in Colonel Lambton's operations were a 36 in. theodolite by Cary; an 18 in. repeating theodolite by the same maker; a 5 ft. zenith sector by Ramsden; two steel chains by the same maker; a standard brass scale by Cary; and several small theodolites by different makers, for minor purposes. These instruments were the finest that the state of art at the commencement of the present century could produce. The great theodolite received an injury in the year 1808, while it was being hoisted to the summit of a lofty pagoda in Tanjore, and it was repaired by Colonel Lambton himself, who, to the duties of an astronomer and surveyor, had, throughout his operations, to combine those of a mathematical instrument maker. Colonel Everest, in an account published by him in 1830, of the measurement of an arc of the meridian, etc., states that "in the commencement of the Great Trigonometrical Survey in 1799 one steel chain by Ramsden was the only measuring apparatus. The history of this was rather singular. It had been sent with Lord Macartney's embassy as a present to the Emperor of China, and, having been refused by that potentate, it was made over by his Lordship to the astronomer, Dr. Dinwiddie, who brought it to Calcutta for sale, together with a zenith sector (a beautiful instrument, *for that time*, by Ramsden). The purchase of both was made by Lord Clive, the Governor of Madras, at the instance of the Earl of Mornington, Governor-General of India." The work of measuring a base line was commenced on the 10th April, 1802, on a plane near St. Thomas Mount, Madras, at no great distance from the shore, and nearly on the level of the sea. The length of the base, reduced to the level of the sea, and to the temperature of 62 deg., is 40,006.44 ft., or 7.546 miles; the latitude of the north end was 13 deg. 00 min. 29 sec., and it made an angle of little more than 12 min. with the meridian. Captain Lambton used a chain similar to one already employed by General Roy on the Ordnance Survey in England. It was made of blistered steel, in 40 links of $2\frac{1}{2}$ ft. each. The chain was laid in coffers or long boxes, supported on stout pickets driven into the ground, and their heads dressed even by means of a telescope. At one end of the chain was the draw-post, to the head of which the near end of the chain being fastened, could be moved a little backwards or forwards by means of a finger-screw. Near the handle of the chain, and at the point where its measuring length was supposed to commence, there was a brass scale with divisions, which was fixed to the head of another picket, distinct both from the draw-post and from those supporting the coffers. This scale could, by means of a screw, be moved backwards and forwards on the head of the post, till it coincided with the mark on the chain. A similar arrangement was made at the other end, but the handle of the chain, instead of being firmly attached to the *weigh* post, as it is called, had a rope passing over a pulley; and to this rope was appended a weight of 28 lbs., to keep the chain stretched. This arrangement enabled the measurer to move his chain backwards and forwards with the greatest nicety, and, when satisfied that it was correctly placed, to keep it there perfectly steady; while, by means of the registers, he marked exactly the places of the two extremities of the chain. The chain was then taken forward, and the near end being adjusted to the scale which had before marked the fore end, a new chain's length was laid off, and so on till the base was finished. Thermometers were placed in the coffers to determine the temperature of the chain; and the rate of expansion being previously determined by experiment, the necessary corrections were made for the varying temperature of the measurement. The quantity of this correction had been found to be on 100 ft. .0075 in. for every 1 deg. of Fahr.: but Captain Lambton, by some experiments previously performed with the chain, found .00725, which quan-

tity he applied as the correction of his measurement. Besides the original chain, a second was obtained from England exactly similar. Its length had been fixed in the temperature of 50 deg. This chain was preserved as the standard, and to its indications were reduced all the measurements made with the other.

In May, 1804, a base of verification of 39,793.7 ft. was measured at Bangalore ; and though the distance was nearly 160 miles, the computed and measured lengths of this base differed only 3.7 in., or about half an inch in a mile. This base was adopted for the origin of the Great Indian Arc series. From it triangles were carried across the peninsula to the opposite coast, and a meridional series was also commenced on a meridian about 35 miles west of Madras, which was subsequently abandoned for the meridian of Dodagontah, further to the west, and on which the Great Indian Arc series was gradually established from Cape Comorin up to latitude 29½ deg. north, being the largest arc yet measured on the earth's surface. Col. Lambton's operations detected an error of no less a quantity than 40 miles in the breadth of the peninsula, as previously laid down astronomically, and all the principal places on the old maps, which had been fixed astronomically, were found considerably out of position. Thus, Arcot was out 10 miles, and Hyderabad no less than 11 min. in latitude and 32 min. in longitude. The distance from Madras to the opposite coast, in the same parallel, was found to be 360 miles, very nearly ; whereas the best maps, till then, had made it exceed 400 miles. The triangles were contrived so as to avoid, as much as possible, very acute and very obtuse angles, and the sides of many were from 30 to 40 miles in length. In computing the sides, Colonel Lambton reduced the observed angles to the angles of the chords, according to the method of De Lambre ; and although he computed the spherical excess, he did not use it in any other way than as a measure of the accuracy of his observations. The chords, which were the sides of the triangles, were then converted into arches ; and, as Major Lambton had contrived that the sides of the 4 triangles which connected the stations at the south and north extremities should lie very nearly in the direction of the meridian, their sum, with very little reduction, gave the length of the intercepted arch, which was thus found to be 95,721.326 fathoms. By a series of observations for the latitude at the extremities of this arch made with the zenith sector, the amplitude of the arch was found to be 1.58233 deg., by which, dividing the length of the arch just mentioned, Colonel Lambton obtained 60,494 fathoms for the degree of the meridian bisected by the parallel of 12 deg. 32 min. This, till the survey was extended further to the south, was the degree nearest to the equator (excepting that in Peru, almost under it) which had yet been measured, and was, on that account, extremely interesting. The next object was to measure a degree perpendicular to the meridian, in the same latitude. This degree was accordingly derived from a distance of more than 55 miles, between the stations at Carangooly and Carnatighur, nearly due east and west of one another. Very accurate measures of the angles which that line made with the meridian at its extremities were here required, and these were obtained by observations of the Polar Star when at its greatest distance from the meridian. For this purpose a lamp was lighted, or blue lights were fired, at a given station, the azimuth of which was found by the Polar Star observations, and afterwards its bearing in respect of the line in question. Thus the angle which the meridian of Carangooly makes at the pole with that of Carnatighur, or the difference of longitude of these two places, was computed. It was then easy to calculate the amplitude of the arch between them, and thence the degree perpendicular to the meridian at Carangooly was found to be 61,061 fathoms.

Between the years 1802 and 1815 Col. Lambton covered the whole country as high as 18 deg. latitude with a network of triangles, whereby the peninsula was completed from Goa on the west to Masulipatam on the east, with all the interior country, from Cape Comorin to the southern boundaries of the Nizam's and Mahratta territories. For a long period these operations were frequently interrupted by the disturbed political condition of the country, which was often the scene of warlike operations. The mysterious character of the instruments and operations, as well as the planting of flags and signals, always more or less awakened the apprehensions or excited the jealousy of native

princes, and it required, therefore, no ordinary tact, firmness, and patience on the part of the head of the department to secure good-will. The area comprised by the whole of the operations prosecuted during the time Colonel Lambton was superintendent aggregated 165,342 square miles. The expense incurred amounted to Rs. 835,377, consequently the rate at which the triangulations were executed averaged Rs. 5 0 10, or less than 10s. per square mile.

In October, 1817, the Marquis of Hastings, impressed with a well-founded conviction of the important utility of the Trigonometrical Survey, resolved to transfer the control over its operations to the Supreme Government of India; and in consideration of Colonel Lambton's increasing age and infirmities, Captain (subsequently Colonel) Everest was appointed to assist him. Captain Everest joined the appointment in 1818, and the Great Arc triangulation was subsequently extended nearly to Takal Khera, in latitude 21 deg. 6 min. The greater part of the Nizam's eastern territories was triangulated by meridional series between the Kistnah and Godavery, and considerable progress was made in the longitudinal series from the Beder base line towards Bombay. Upon Colonel Lambton's death, Captain Everest succeeded to the office of superintendent, and he immediately proceeded to concentrate all the resources at his disposal on the extension of the Great Arc series, which, after many difficulties, was at length carried up to latitude 24 deg., where a base line was measured at Seronj. Col. Everest then proceeded to England on sick leave, and during his absence a longitudinal series was extended from the Seronj base line towards Calcutta. This series was eventually brought to a close in the year 1832, at the Calcutta base line, having occupied a period of 6 years in accomplishing a direct distance of 671 miles. In 1830, Colonel Everest returned to India, liberally provided with geodetical instruments and apparatus of every description, comprising a complete base line apparatus, the invention of Colonel Colby, precisely similar to that employed on the Ordnance Survey; a great theodolite, 36 in. in diameter, designed by Troughton, to 18 in. theodolites, and a variety of smaller instruments from 12 in. diameter downwards, all of which were manufactured by Messrs Troughton and Simms. The signals, all of the most efficient kind, and recently invented, consisted of heliotropes, reverberatory lamps, and Drummond's lights, of which the two former have been exclusively used. The substitution of luminous signals for opaque ones contributed vastly to the subsequent improvement of the observations. Alterations in the departmental arrangements, official delays, and the measurement of the Calcutta base line, occupied Colonel Everest until the end of 1832, from which time the Great Arc may be considered to have actually recommenced after a cessation of 7 years. The work was carried on unremittingly till December, 1841, when the whole Indian Arc, from Cape Comorin to the Himalaya Mountains, forming the main axis of Indian geography, was finally completed.

The Calcutta base line was measured upon a broad road leading from the Government House in Calcutta to the Government Palace at Barrackpore, which immediately on emerging from the suburbs is sufficiently straight for about six miles and a half. Calcutta and its vicinity, and in fact all places in Lower Bengal, being so encumbered with lofty trees and dwelling-houses as to restrict the view to a very short distance, and as these could not be removed, there was no other mode of carrying on trigonometrical operations than by raising both ends of the geodetical line so as to overtop these obstructions. Two towers of 75 ft. high each were accordingly erected at either limit of the Calcutta base, whereby it was connected with the triangulation. This base was the first occasion on which the new compensation bars were brought into use in India.

The area comprised by the Great Arc operations, principal and secondary, aggregates 56,997 sq. miles, including the revision of the section from Beder to Kalianpoor, and the measurement of 3 base lines, each from 7½ miles to 8 miles in length, viz.: those of Beder, in latitude 18 deg.; Seronj, near Kalianpoor station, in latitude 24 deg.; and the Dehra base, about 70 miles north of Kaliana station, in latitude 29.30 deg., where the Great Arc actually terminates. On comparing the actual measurement of the Dehra Dhoon base, by Colby's apparatus, with that calculated from the Seronj base,

measured in 1824 by a chain, a difference of nearly $3\frac{1}{2}$ ft. was found. Colonel Everest, justly considering the difference as indicating a much larger errror than ought to exist, resolved to re-measure the old base with the more accurate apparatus he now had at his command. This operation was completed in January, 1838, when it appeared that the length given by the chain measurement of 1824 was too short by nearly 3 ft., as compared with the new result. The Dehra Dhoon base is nearly $7\frac{1}{2}$ miles in length; the ground is undulating, and by no means favorable; the line is twice intersected by the stream of the Asan, and the height above the sea level of one end of it is 186 ft. greater than at the other. The base was measured twice, first from west to east, and then in the opposite direction. After all reductions the two results were as follows: Length in feet at the level of the sea—by measurement, 39,183.97329; by the re-measurement, 39,183.77357; difference, 0.19972, corresponding to $2\frac{4}{10}$ in. nearly. Another test was applied with an equally satisfactory result. The entire line was divided into 3 sections, and the two end sections deduced from the middle one by triangulation. The discrepancies between the measured and computed distances were + 0.33 in. in the one case, and —0.078 in. in the other; so that the whole base, deduced in terms of the middle section, differed from the length actually measured by scarcely more than a quarter of an inch. The other two bases, at Seronj and Beder, were measured exactly in the same manner as that in the Dehra Dhoon. In the case of the Beder base (nearly 8 miles) the measurement was tested by dividing the whole length into three sections and computing the two end sections from the middle one by a triangulation. The difference was found to amount only to an inch in the one case, and about two-thirds of an inch in the other; the computed length exceeding the measured length in both cases.

Great importance was attached to the construction of the stations. Throughout the Doab it was necessary to erect artificial structures of sufficient height to overtop the trees, and of sufficient solidity to afford a firm support to the theodolite. These were of a very substantial kind—square towers of solid masonry, about 50 ft. in height, with walls 5 ft. in thickness at the foundation, and 2 ft. at the top. A stone slab, supported on two transverse stone beams, formed the floor on which the instrument stood; and the stage for the observers was entirely disconnected, in order to avoid vibration while the observations were going on. The centre of the station was carefully defined on a plate of metal let into a stone, and sunk in the ground for further security; and the theodolite and signals were in all cases accurately adjusted over the centre. The sites of stations were also carefully selected with a view to well-conditioned triangles. It was a general rule, steadily adhered to, that no angle of any triangle should be less than 30 deg. The sides of the triangles may be stated to be from 10 to 25 miles, and in a very few instances only are they found so much as 30 miles. In order to eliminate errors and obtain results of uniform precision, the angles were measured from 8 different zeros on the circle, the established rule being "to observe three times at each zero with the face left, and as many with the face right; then to change the zero three times by 9 deg. each time, and at each position to go through a like operation, whereby it is evident that every ninth degree will in turn fall under one or other of the microscopes." For computing the sides of the triangles, the theorem of Legendre was used with the following results: The length of the Dehra Dhoon base, brought out by computation from the Seronj base, was found to be 39,183.273 ft., and by actual measurement 39,183.873 ft., the difference being 0.600, six-tenths of a foot, or a little more than 7 in., the distance between the two bases being about 430 miles. Again, the Beder base, brought out by computation from the Seronj base, was found to be 41,578.536, the difference in this case being only 0.358 parts of a foot, or a little more than 4 in., the distance between the two bases being about 426 miles, and the calculation made through 85 principal triangles. The relative heights of the stations were determined by means of observations of their vertical angles, as seen from each other, made with 18 in. altitude and azimuth circles. For deducing the amplitude of the northern section, Seronj to Kaliana, 36 stars were selected, half of them to the south and the other half to

the north of the zeniths of both stations, but none of them having a zenith distance exceeding 5 deg. from the nearest vertical. For the southern section 32 stars were observed at Seronj and Beder.

In the year 1829 a trigonometrical survey in the Bombay Presidency was commenced by Lieutenant Shortrede on an independent base and point of departure. Finding that no use could be made of this confused net of triangulation, Colonel Everest directed, in 1831, that the longitudinal series should be taken up where he left off in 1823, at the time of Colonel Lambton's death. The Bombay longitudinal series was brought to a conclusion in 1841; it extends 315 miles in length, and occupied 12 years.

Immediately after the measurement of the Calcutta base line several parties were fitted out with the view of carrying on triangulations in different directions; but it is not our purpose here to follow each of these parties in their operations, as that would occupy too much space, and be of but little interest to most of our readers. In his report on the general state of the work up to 1850, Colonel Waugh (who had succeeded Colonel Everest as Surveyor-General of India and Superintendent of the Great Trignometrical Survey), remarking upon the accuracy attained by the modern operations, observed that in the large triangulation, where of course the greatest refinement and most scrupulous care is observed, an error of 1 in. per mile, or $\frac{1}{63360}$ part, amounts to 500 in., or 42 ft., or nearly half a second in arc of latitude or longitude in 500 miles, which distance is even exceeded between some of the bases. The work is reckoned liable to half this error when executed with the great theodolite, on the principle of double series; the results attained by the new 24 in. theodolites are but little inferior to this degree of accuracy. When the series are single, the liability to error is reckoned to approach nearer to 1 in. per mile; when performed with good 18 in. theodolites the error will exceed 1 in. per mile, according to the character of the graduation. With inferior instruments, or a less careful system, the accumulation of error would approach a foot per mile, which is equal to a ratio of $\frac{1}{5280}$ in linear dimension, or $\frac{1}{2640}$ in area, or $\frac{1}{20}$ per cent., or six seconds of arc in the above distance.

Sir Andrew Waugh, who succeeded Colonel Everest, held the appointment of superintendent of the Great Trigonometrical Survey for 17 years, and on his retirement was succeeded by Colonel J. T. Walker, R. E., as superintendent of the Great Trigonometrical Survey, and by Colonel Thullier, R. A., as Surveyor-General of India, both which officers respectively fill those appointments at the present time.

In the principal triangulation of India a gridiron system is followed, similar to that adopted in the French and Russian surveys, consisting of chains of large triangles extending along the principal meridians and the course of the eastern and western frontier, and connected with other chains of longitudinal series, the northernmost of which follows the Northern British frontier, while the others run along certain parallels of latitude at convenient intervals. Colonel Everest's Meridional Arc, which extends from Cape Comorin to the Himalayas, over a length of upwards of 22 deg., from its central position and intrinsic value, naturally forms the axis of the system. Base lines are measured at the extremities of the longitudinal chains, and at the points where the chains cross Colonel Everest's arc. Thus the triangulation is divisible into large quadrilateral figures, with a base line at each corner. Nearly all the principal series of triangles consist of double figures (polygons or quadrilaterals) for mutual verification, and to reduce the accumulation of error to a minimum. The length of the sides of triangles in the plains is on an average about ten miles, and the greatest care is taken to obtain symmetrical figures. In hilly country the lengths of sides vary considerably. The instruments used for the principal trigonometrical operations are the great theodolites, having azimuthal circles of 24 in. to 36 in. diameter, with 5 microscopes, and vertical circles of 15 in. to 18 in. diameter, with 2 microscopes. The signals to which observations are taken are luminous—heliotropes by day and lamps by night. The secondary triangulation is conducted with vernier theodolites, having azimuthal circles of 14 in. to 8 in. diameter; the signals are both luminous and opaque, according to the nature of the work required. The base lines are measured by means of sets of

compensating bars and microscopes, on the principle of those designed by Colonel Colby for the Ordnance Survey of Great Britain. The other general operations of the Great Trigonometrical Survey comprise: topographical surveys of the Himalayas and of the province of Kattywar, geographical explorations of Trans-Himalayan regions, astronomical observations for determining latitudes of stations of the triangulation, levelling operations, geodetic and magnetic observations for determining, at certain stations of the Great Arc, the number of diurnal vibrations of two pendulums, the property of the Royal Society of London, and measuring the magnetic dip, declination, and total force at the same stations.

The head-quarters office at Dehra comprises two principal branches, viz., the computing office, with a *personnel* of an officer in charge, 3 European assistants, and 12 native computers employed in the examination, reduction, and publication of the trigonometrical and astronometrical observations. This branch of the office also undertakes monthly magnetic and daily meteorological observations at Dehra, and, during the recess, at Masoori, comparison of standard thermometers and barometers, and other scientific operations. The other branch consists of a drawing office, for the preparation and publication of the various charts and maps emanating from the trigonometrical operations and explorations in progress, under the direct control of the superintendent. The Dehra office also comprises a printing-office and a small photozincographic establishment for the reproduction of maps and charts by photozincography, or simple zincography. The photozincography process used is almost identical with that used at the Ordnance Survey Office at Southampton, and is found to work very successfully in the comparatively fine climate of Dehra. The charts of the trigonometrical operations are zincographed on a scale of 4 miles to the inch, and the geodetical co-ordinates for each station, with azimuths and linear distances, are entered upon them, so that each chart forms a brief but complete record of the survey results. Skeleton charts of levels on a scale of 2 miles to the inch are also prepared and photozincographed. These show the combined results of both trigonometrical and spirit levelling reduced to the common datum of the mean sea level of Kurachee harbor. The maps and plans prepared under the direction of the superintendent, Great Trigonometrical Survey, vary in scale. The greater number are photozincographed at his head-quarters, and a few are lithographed at the Surveyor-General's Office, Calcutta.

The ground-work or basis of the operations of the Topographical Survey is secondary and minor triangulation dependent on the Great Trigonometrical Survey operations, from which all the initial elements of latitude, longitude, elevation, distance, and azimuth are derived. The triangulation is carried on in a network covering the ground with points or stations at about 3 to 4 miles apart. The instruments employed for the secondary triangulation are vernier theodolites with 12 in. and 14 in. azimuthal circles; the horizontal observations are taken on 4 zeros repeated, and the vertical angles on 2 zeros. For the subsidiary, or minor network of triangles, theodolites with 7 in. and 8 in. azimuth circles are used, and the angular measurements are made with 2 zeros repeated. The detail work, or delineation of the configuration of the ground, is executed usually on the moderate scale of 1 in. to the mile; some topographical surveys in cultivated and valuable tracts are, however, on a scale of 2 in. to the mile, whilst a few others in very broken and wild ground are on the scale of ½ in. to the mile. In addition to these surveys, the topographical branch undertakes the plans of all the important cities, forts, and strongholds in native states, which are mapped on scales varying from 6 in. to 16 in. to the mile.

The Revenue Survey of the Bengal Presidency is a scientific periphery admeasurement of the land by means of angular and linear measurements, performed with theodolites and steel chains. It is a definition and survey of village boundaries and estates, and may also be termed a large scale topographical survey, as it affords accurate topography of every district falling within the scope of its operations, and is admirably adapted to all open and champaign districts. The system followed by the Revenue Survey is that of traversing with the theodolite and steel chains, known as Gale's method of land surveying, modified to secure greater accuracy and efficient checks on both the

boundary and interior detail measurements. Large areas are first traversed with the better class of small theodolites, starting from an initial station, where the azimuth is observed, to obtain the true bearing of the stations in advance. These areas are called main circuits, and they are subsequently subdivided into minor or block circuits; these minor circuits being in their turn traversed and proved true on the basis of the main circuit containing them. The interior, or detail survey, which is filled in by plane table or compass and chain, rests upon these small village polygons, plots of which are furnished to the native plane tablers. The field mapping is all executed on a scale of 4 in. to the mile.

In the Presidencies of Madras and Bombay minute cadastral measurements of fields are in progress under European officers; these surveys are essential for settlement and revenue purposes, and have no connection with the Indian Survey Department, nor are they under the direction of the Surveyor-General of India.

COMPARATIVE EFFECTS OF GUNPOWDER AND GUN-COTTON.

From "The Mechanics' Magazine."

A number of experiments have been recently carried out by the officers of the Royal Engineers at Chatham to test the comparative effects of gunpowder and gun-cotton in various operations. The experiments were all under the direction of Colonel W. O. Lennox, C. B., V. C., Instructor in Field Fortifications at the School of Military Engineering, assisted by a number of other officers. The experiments were attended by a large muster of officers of the garrison, besides those of the Engineer Corps, and also by Major-General J. L. Brownrigg, C.B., the commandant of the garrison; Colonel Wray, Colonel Graham, C.B.,V.C.; Colonel Fiser, Colonel Lovell, commanding Royal Engineers; Colonel the Hon. H. F. Keane, Deputy-Adjutant-General Royal Engineers; Colonel Clarke, etc. Mr. F. A. Abel, chymist to the War Department, was also present and assisted in some of the experiments with gun-cotton. The experiments commenced with explosions of gunpowder and gun-cotton directed against a double stockade of balks of timber 14 in. square, 3 ft. 6 in. apart and sunk 3 ft. in the earth, each line braced together by strong cross pieces. A charge of 200 lbs. of gunpowder, in bags merely laid at the foot of the stockade, untamped, was first exploded. It forced a large gap in the front stockade, but, though partially shattered, the second row of timber would have presented a formidable obstacle to an attacking party if defended by a few resolute men. Portions of the timber were hurled through the air to some distance. A charge of 80 lbs. of gun-cotton was next laid in bags at the foot of the stockade, some distance from the former explosion. This also was untamped. It was fired by a detonating fuse. There was a terrific explosion, and an almost perfectly clear breach was made through both rows of timber, practicable for an attacking party to get through. The effect was very much superior to that of the 200 lbs. of gunpowder. Immense pieces of timber were hurled through the air to a great distance, mostly in the rear of the stockade. Not so wide an extent of timber appeared to be shaken as by the first explosion, but the work was more completely done; the results, indeed, were extraordinary. Experiments were also made by exploding discs of gun-cotton against single balks of timber, to show what effect would be produced if timber bridges had to be destroyed. Four balks of timber, about 16 in. square, were sunk in the ground some feet apart, in a square, and braced together by thick pieces of plank. A "necklace" of small discs of gun-cotton was formed (about 68 in number); this was doubled and placed half round one of the timbers. The explosion of this string of discs tore away the wood for some depth, 4 in. or more on one side of the balk, but did not break it, though the massive timber was much rent. Three or four larger discs were then exploded on one side of the timber, and tore out a large portion of the wood. A single "necklace" of small discs, 65 in number, and weighing $2\frac{1}{2}$ lbs., was then placed round another balk, quite encircling it. When exploded this tore out the wood all

round to some depth. Then 12 of the larger discs, weighing 4 lbs. 2 oz., were hung on nails on three sides of the timber, and exploded. The explosion was very powerful, and the large balk was cut in two—snapped off where the gun-cotton had been attached, but falling on the side where there had been no discs and partially splitting on that side. The spectators cheered at this decisive proof of the value of gun-cotton for this special purpose. All these experiments appeared to be very satisfactory. At that part of the lines in front of St. Mary's Barracks, a number of mines and galleries had been excavated and charged with gunpowder or gun-cotton. One mine had a charge of 500 lbs. of gunpowder; a second similar mine was charged with 200 lbs. of gun-cotton. Two smaller mines were charged respectively with 21.6 lbs. of gunpowder and 8.6 lbs. of gun-cotton. These mines were successively exploded by means of an electric current. In the larger mines the powder appeared to be the most effective agent. In the explosion of the 200 lbs. charge of gun-cotton, a peculiar effect was produced; first, there was the eruption of brown clay and smoke, and then a large flame, produced by the ignition of the gaseous products of the explosion. The officers then proceeded to the old Engineer Depot, near St. Mary's Convict Prison, and walls which are to be removed were experimented upon; they are 18 in. thick; charges of gun-cotton ranging from 2 lbs. to 3½ lbs. were exploded against these walls, with satisfactory results, making breaches in them. The officers then returned to the scene of the mines, where two long galleries had been prepared, one charged with 240 lbs. of gunpowder, the other with 96 lbs. of gun-cotton. These charges were exploded. The object was to ascertain if it is practicable to form trenches in this manner, instead of throwing them up while exposed to the enemy. It was thought by some officers that the explosions would throw the earth up on either side in such a manner as to form a trench; but the result was not so—the earth was thrown up in a mass, and no trench was formed in which men could get under cover at once.

The experiments created the greatest interest among those who witnessed them, and were highly satisfactory.

OCCLUSION OF GASES BY ELECTRO-DEPOSITED IRON.

From "The Engineer."

M. Lenz has published at St. Petersburg a very interesting paper on an investigation which he made of the properties of iron thrown down in the metallic form from its solutions by a battery, and the chief results of his inquiry are given below. Iron deposited by a galvanic current is noted for its hardness, color, texture, and capacity for occluding gases. The specimens that M. Lenz employed in his researches were obtained by Klein's method from a solution of protosulphate of iron with which sulphate of magnesia had been mixed, by aid of a weak current, the solution being kept neutral by carbonate of magnesia. Under these conditions the deposit has a beautifully fine granulated structure, in which the microscope failed to detect any crystalline characters. The color is a soft, brilliant gray, the hardness 5.5, which means that the iron scratches apatite and is scratched by felspar. During deposition, even when a *thick* copper plate (a Daguerreotype plate) was used, this plate begins to bend as soon as the iron has attained a certain thickness, the concave side being turned towards the other electrode. If the copper plate be very thick, or the iron quite thin, no contortion, it is true, is observed, but that there is an inclination to do so will be remarked on dissolving off the iron from the copper. The plate in bending takes the form of the face of a cylinder whose axis is horizontal. If the iron be slowly deposited on a polished face it presents, when thin, an unbroken surface with a velvet-like aspect; as it grows thicker it becomes vesicular, and little depressions of an oval form are observed.

The iron thus prepared loses many of its characteristics by being heated over a charcoal fire. Its hardness sinks to 4.5, and though when newly deposited it was exceedingly brittle, it now possesses the

opposite character in a very marked degree. Thin films recently deposited can be easily crumbled between the fingers; after they have been heated, however, it is quite impossible to do this. They may be torn or cut with scissors, as we can tin-foil, but broken they cannot be, though bent backwards and forwards repeatedly along the same line. The plate of iron has acquired greater powers of durability than a sheet of paper possesses when submitted to similar manipulation. When heated in vacuo, or in an atmosphere devoid of oxygen, the iron becomes as white as the platinum used for chemical apparatus. Iron ignited in this way rusts quickly, both in air and in water whose air has been expelled by boiling. In the latter case the water becomes green in a few minutes, and after some hours its surface is covered with a layer of rust; if, on the other hand, deposited iron be taken which has not been heated, but few spots of rust make their appearance under the like circumstances of exposure. As the metal rusts, gas is absorbed, and it is probable that a decomposition of water takes place.

Again, as regards their electrical characters, the ignited and non-ignited iron comport themselves very differently. A galvanic element was formed with a solution of caustic potash, and two plates of iron, one of each kind; or each of these was in turn replaced sometimes by a plate of zinc and sometimes by one of copper. The strength of the current was determined galvanometrically, and as the plates were in all cases placed at one and the same distance apart, the result of the galvanometric measurements may be taken as a measure of the electromotive force. Below are the results:

	Deflection of needle.
Ignited iron and non-ignited iron......	− 6
Copper and non-ignited iron...........	− 9
Copper and ignited iron......	+ 11
Copper and zinc....................	+114
Ignited iron and zinc................	+114
Non-ignited iron and zinc.............	+ 91

The volume of gas removable from the iron by the application of heat and the aid of the air-pump varied according to the thickness of the plate between pretty wide limits, one volume of iron taking up from 20 to 97 volumes of gas. It consisted of hydrogen, nitrogen, carbonic oxide, carbonic acid, and aqueous vapor. To determine their volume the iron was cut into small strips, introduced into a porcelain tube, which was closed at one end, and communicated at the other with a Sprengel's aspirator. Exhaustion at ordinary temperature drew out no gas whatever; the tube was finally brought to a white heat in a charcoal furnace, and the liberated gases examined by the method which Bunsen has given in his "Gasometry." The results of the analysis of the gases from four specimens of iron are given below. No. 1: Iron precipitated on a brightly polished Daguerreotype plate, of extremely fine grain, not vesicular. Thickness of metal, 0.08 mm. No. 2: Iron plate prepared by Klein by the method in use at the Russian State Paper Office. Surface finely granular, and distinctly vesicular. Thickness, 0.125 mm. No. 3: A similarly prepared plate, of equally fine grain. Thickness, 0.14 mm. No. 4: Plate deposited by extremely weak current. Thickness, 0.27 mm.

	1.		2.		3.		4.	
	Volume of gas, that of iron being 1.	Percentage composition.	Volume of gas, that of iron being 1.	Percentage composition.	Volume of gas, that of iron being 1.	Percentage composition.	Volume of gas, that of iron being 1.	Percentage composition.
Hydrogen, ...	52.2	53.4	15.8	68.7	12.8	60.4	12.0	58.3
Nitrogen,..........................	15 2	15.5	0.8	3.5	1.2	5.6	1.2	5.8
Carbonic oxide, ...	14.7	15.1	5.5	23.9	5.7	26.7	3.6	17.4
Carbonic acid,.................	12.4	12.7	0.4	1.7	0.9	4.3	2.8	13.6
Aqueous vapor,......................	3.2	3.3	0.5	2.2	0.6	3.0	1.0	4.9
Total, ...	97.7	100.0	23.0	100.0	21.2	100.0	20.6	100.0

The carbonic acid and carbonic oxide are evidently derived from the solution out of which the metal is deposited, for to neutralize the excess of acid carbonate of magnesia was added from time to time; and the nitrogen must have been obtained from the same source. The percentage of these three constituents varies in a remarkable degree, and the same is true of the absolute amount of gas occluded. It is evident that the thickness of the deposit exerts an influence here, for the thinnest film of metal (0.08 mm.) absorbed 97.7 volumes of gas, and with an increasing thickness of the plate the relative amount of gas is seen to diminish. It follows from this that the greatest amount of gas is taken up at the commencement of the operation. To determine this more accurately some special experiments were made. Two silvered copper plates had lines drawn lengthwise on them, dividing on one plate the surface into three equal parts, and on another its surface into four equal parts. They were then immersed in the bath and covered with a thin film of metal. One division after another was now coated with varnish, and the plate again immersed in the iron solution, so that the last film became the thickest. The varnish having been removed with alcohol, the plates were broken into three and four parts respectively along the lines, and the gas occluded by each portion determined. Finally, from the results of these analyses, it was an easy matter to calculate how much gas was absorbed when a plate increased 0.01 mm. in thickness. The numbers are as follows:

	Exp. 1.	Exp. 2.
0.01 mm. thickness of the first layer absorbed	18 c.c.	17 c.c.
0.01 mm. thickness of the second layer absorbed	4 "	9 "
0.01 mm. thickness of the third layer absorbed	3 "	6 "
0.01 mm. thickness of the fourth layer absorbed	—	4 "

To the more abundant occlusion of gas by the first layer of iron must be ascribed the contortion attending deposition, as well as the circumstances that, after a certain thickness of metal has been reached, the formation of vesicular metal seems unavoidable. The rusted iron was also subjected to a searching inquiry, and it was shown that during oxidation water was decomposed and hydrogen absorbed. A fragment of the iron used in Experiment 2 was freed by powerful ignition from all gas, and immersed four days in water. The rust having been removed as completely as possible, it was heated to a bright red heat in the tube of the Sprengel's aspirator. The gases extracted were 2.54 volumes of hydrogen, 0.06 volume nitrogen, 0.02 volume carbonic oxide, 0.053 volume carbonic acid, and 0.067 volume aqueous vapor, or 3.82 volumes in all. The comparatively large amount of watery vapor was supposed to be due to the rust that could not be removed completely, and whose oxygen at the high temperature of the experiment would convert some of the liberated hydrogen into water. Assuming this to have been the case, the hydrogen would amount to 3.21 volumes, or 84.0 per cent. of the gases liberated. Iron deposited by a battery, then, possesses the property of decomposing water, and absorbing hydrogen thus set free.

M. Lenz examined the comportant of copper when deposited by a battery. He found the gases occluded by this metal to be 3.4 volumes of hydrogen, 0.37 volume carbonic oxide, 0.49 volume carbonic acid, and 0.14 volume watery vapor, or 4.4 volumes of gases in all; or in other words, he has shown that copper, when deposited, absorbs gases, the greater part of which is hydrogen.

The railway bridge at Strasbourg has been rendered impassable by removing a sort of drawbridge on the French side. It is stated that on the Baden side this arrangement could not be made, and so their share of the bridge is already mined, to be blown up, if necessary, at a moment's notice.

Parliamentary powers will, it is said, be sought to authorize the formation of an embankment along the foreshore at Cremorne, with a view to the continuation of the Thames Embankment from its authorized termination at Chelsea to the northern end of the Battersea Bridge.

Measures have at length been taken for the preservation of fish in the canals of India by limiting the meshes of the nets.

OUR SYSTEM OF MILITARY BRIDGES.

From "The Engineering and Mining Journal."

The safe and rapid passage of rivers in the field is one of the most important and delicate of military operations. Instances might easily be cited, not only in our late war, but in many others, where, through the absence of a proper pontoon train, the most brilliant opportunities have been lost.

Our own system of military bridges is not a superficial and sudden creation. It is the result of careful study, patient and long-continued experiments, and great experience in the field. In December, 1868, the Chief of Engineers of the United States Army, organized a Board for the purpose of improving and revising the bridge-system. This Board was composed of officers of long and distinguished connection with the Engineer service; and the result of their labors is now issued, under authority of the Secretary of War, as the improved system of drill and instruction for the line of the United States Engineers. The book is accompanied by an atlas, containing a large number of working drawings, sufficiently in detail to serve for the construction of the complete train.

In order to give an idea of the system adopted, and the reason which induced the Board to recommend it, we select from the report a few facts concerning the bridge-train and its history. Previous to the Mexican War no attempt was made to organize a bridge-equipage in our service. During this war two complete trains of india-rubber pontoons were constructed and sent into the field. At its close, those trains were sent to West Point, where they were used for the instruction of cadets and engineer troops. A full description of this equipage is given in the "Professional Papers, Corps of Engineers, No. 4."

It soon became evident that india-rubber is not at all adapted to the construction of pontoons.

First.—From the perishable nature of the material. The cylinders are formed of alternate layers of canvas and india-rubber. The sulphur used in the process of vulcanization generates sulphuric acid, which soon destroys the fabric of the cloth.

Second.—The extreme elasticity of this species of support gives to the bridge a rocking and oscillating motion, so violent as to render it unsafe for the passage of animals.

Third.—The most serious objection, however, is that a puncture, either above or below the water-line, is equally fatal to the cylinder. Hence, a single sharp-shooter, from a rifle-pit on the enemy's side of the stream, can destroy these pontoons as fast as they are launched.

In the autumn of 1858, the india-rubber pontoons having become entirely unserviceable, experiments were made to determine the composition of a bridge-equipage that should be adapted to our service. In conducting these experiments, the following fundamental rules were kept constantly in view.

First.—The mobility of the train must be such as to enable it to keep pace with all the movements of the column to which it is attached.

Second.—The train should furnish the means of ferrying troops promptly and safely, as in the case of disembarkation, and the passage of a river by force.

Third.—It should furnish the means of constructing a bridge capable of passing an army with all its trains over the largest and most rapid rivers, with safety and without delay.

Now, under the most favorable circumstances, it is very difficult to reconcile the first and third of these rules, when but one species of pontoon is employed. In this country it is impossible. The immense trains with which our armies are unavoidably encumbered, the long marches to be made, and the numerous wide and rapid rivers to be crossed, demand an equipage of the most substantial character. On the other hand, the extended expeditions of light columns, which necessarily attend our military operations, require a train light enough to keep pace with the most rapid cavalry movements.

Hence we require both a reserve and an advance-guard train.

The experiments above named included the trial of samples of the bridge equipages used by those European armies most experienced in the art of military bridge

building. Pontoons were constructed after the models of the French bateau, the Austrian sectional pontoon, and the Russian canvas-boat. Corrugated-iron boats were procured corresponding as nearly in form and dimensions to the French and Austrian boats as the nature of the material would permit. A number of Birago trestles were also constructed. All of the above material, with the exception of the iron boats, was prepared by the enlisted men of Company A, Engineers.

The bridges formed of this varied material were exposed as much as possible to the action of heavy loads, storms, the tide and floating ice. The material was also packed on carriages of various patterns in order to ascertain the best form, both of bridge material and carriage, for transportation.

The selection of the French, Russian and Austrian trains for these experiments, was made after a careful study of the various equipages used at present by the armies of Europe. These three nations alone appeared to have definitely settled on their systems, and this after much experience and thorough research.

The Prussians and Spaniards were seeking for substitutes for their bridges, which had proved unsatisfactory. The Sardinians had adopted a plan inferior to that of the Austrians, though similar in some respects. The English tin pontoon had too many of the defects of the india-rubber to answer our purposes.

After experimenting for two years with the above-mentioned material, the following conclusions were reached : The French pontoon is superior to the Austrian in simplicity and stiffness ; as a ferry-boat, it will transport more troops, and is more easily managed ; in the bridge, its superiority is marked. With the French equipage, the corresponding balks of the adjacent bays lap each other about six feet, and are finally lashed together and to both gunwales of the pontoon, which greatly increases the strength and stiffness of the roadway ; while with the Austrian, the balks must meet on a sill directly over the axis of the boat. The bays thus hinging on this side, full play is allowed to the horizontal and vertical oscillation to which floating bridges are subject.

As to land transportation, the French train requires fewer carriages to transport the same length of bridge than the Austrian, since for each section of the latter pontoon a separate vehicle is necessary. The length of the two carriages does not differ materially, this being determined by the length of the balks.

These considerations led to the adoption of the French pontoon.

The next question was, what material should be employed in its construction ? Life-boats having been successfully manufactured in this country out of corrugated iron, it was presumed that this material could be used with equal advantage in the present case. The first boat, made of the same thickness of metal as the largest class life-boat, proved to be deficient in stiffness when placed in the bridge. The corrugations, running from bow to stern, diminished the power of the sides to resist the vertical strain caused by the weight of the roadway on the gunwales. To remedy this defect it was proposed to line the boat amidships with iron corrugated vertically, or to introduce strong iron ribs.

These expedients, though they would have increased the weight beyond that of the wooden pontoon, might have been successful; but they were not attempted, as the boat failed in other respects. In fact, it would not bear transportation ; as, in travelling over a rough road, the joints open, either the rivets or the sheet iron giving way. When in the bridge, if the boat grounds on an uneven or rocky bottom, a hole is frequently punched through it, and such injuries cannot be repaired in the field. The wooden pontoon is not only much less liable to such accidents, but can be readily repaired when they do occur.

Previous to the battle of Gettysburg, a pontoon bridge over the Potomac at Harper's Ferry was destroyed, the pontoons being scuttled and set adrift above the rapids. About three weeks after, the water having fallen, the boats were recovered, repaired with pieces of hard-bread boxes obtained from the commissary, and used in constructing a bridge at Berlin, over which the entire army passed into Virginia.

With regard to the canvas boat, it soon became apparent that it is precisely what we require for our advance-guard train. It is light, simple, strong, easily repaired, and when packed can be safely transported with the superstructure of the

bridge as rapidly as any column of troops can move. A strong argument in favor of its adoption was that it had been used successfully by the Russians for more than a hundred years, under every variety of circumstances likely to occur in this country.

The selection of the carriage for transporting the bridge material was next taken up. The French pontoon wagon is not adapted to our rough roads. The wheels are too small, and cannot be increased in diameter without raising the load too high above the ground.

A carriage was finally devised on the principle of the four-horse truck used in this city. By means of the horizontal fifth wheel over the front axle, and of an inclined wagon-bed, forward wheels of the requisite size were enabled to reverse completely under the load, thus allowing the carriage to turn in a short space. This construction is absolutely necessary when wagons so long-geared travel over a crooked road.

For the chess wagons and canvas train, a similar wagon would, without doubt, have answered the purpose perfectly, so far as transportation is concerned ; but the ordinary baggage wagon of the Quartermaster's department, with some modifications, was used on account of the facility with which it could be obtained, and the readiness with which spare parts could be procured for repairs in the field.

The Birago trestle, which had been recently adopted by most of the European nations, was also thoroughly tested ; and the result proving favorable, it was proposed to employ it in connection with the pontoons of both trains.

From the information gained by these experiments, there resulted the system of bridge equipage adopted at the commencement of the late war. During the winter of 1861–'62, five trains were constructed, each composed of thirty-four pontoons and 8 trestles, the pontoons being nearly of the same form and dimensions as the French bateau. The frame was somewhat different, the ribs being entire and strongly ironed, and the ironing stronger throughout. The stern was provided with a locker. There were also other alterations in the details of construction. The balks were stronger ; and the Birago trestle was modified by substituting built beams, instead of solid timber, for the trestle-caps and balks.

At the same time several canvas trains were organized. In constructing the pontoon-frame, the dimensions and form of the Russian boat were exactly retained. The scantling for the frame was considerably lighter, but, being strongly braced and ironed, the strength was about the same. One train was composed of canvas boats and trestles ; being, in truth, a trestle train, with auxiliary pontoons to be used only where the depth of water, or muddy bottom, prevented the use of trestles.

In the month of February, 1862, a pontoon bridge, composed of about 60 boats of the reserve train, was thrown across the Potomac at Harper's Ferry. The river was then a perfect torrent, the water being 15 ft. above the summer level, and filled with drift-wood and floating ice. The greatest difficulty was experienced in pulling the pontoons into position, and it was necessary to make use of ship anchors and chain cables to hold them in place. Notwithstanding these unfavorable circumstances, the bridge was completed in about 8 hours, and the corps commanded by General Banks, with all its trains and artillery, passed over it without accident or delay.

Several of these trains accompanied the army in the Peninsular campaign. The pontoons were used in discharging quarter-master and commissary stores at Ship Point, in disembarking General Franklin's command at West Point, and in constructing bridges over Hampton Creek, the streams in front of Yorktown, and the Upper Chickahominy. Finally a bridge was built over the Lower Chickahominy, about 2,000 ft. long, over which nearly the whole army of the Potomac, with its immense trains, artillery and cavalry, passed with promptness and safety.

After the army had passed, the bridge was dismantled and the balks, chess, etc., passed into the pontoons, which were formed into rafts, and towed by steamers to Washington. The bridge-trains were next transported to Harper's Ferry, where a bridge was constructed a second time, but under entirely different circumstances from that built during the previous winter. The water was now not deep enough; and as it continued to subside shortly

after the bridge was laid, many of the pontoons grounded on a very uneven and rocky bottom. Some of them were completely out of water, yet the heavy trains continued to move over the bridge without seriously injuring them ; and when the water rose, most of them floated as well as ever.

Discovering in this way that the boats were much stronger than had been supposed, the engineers were enabled to improve the method of bridging tidal streams.

It had formerly been considered necessary to build out to low-water mark with trestles, so that the pontoon should always be afloat. The bridge is now commenced at high-water mark, building with pontoons alone. As the water subsides, the pontoons nearest shore ground successively, forming a gentle ramp from the abutment to the floating portion of the bridge, instead of making the descent in 20 ft. as formerly. This method, of course, applies only to wooden pontoons, and to cases where the bottom is favorable.

During the Fredericksburg campaign, it became necessary to force the passage of the Rappahannock. The enemy having entrenched themselves on the bank, prevented for some time the construction of the bridge ; until, at length, troops were embarked in the pontoons and ferried across, where they stormed the rifle-pits, and held them until the bridge was completed.

During the year 1863, the pontoon-trains accompanied the army in all its marches backward and forward through Virginia, frequently bridging the Potomac, Rapidan and Rappahannock. In the latter stream, the bridges remained in position all winter, and, notwithstanding the frequent floods and the quantity of ice formed, but few interruptions occurred upon these thoroughfares.

During the campaign of 1864, trains composed of 14 pontoons and 2 trestles accompanied each of the 3 army corps of the army of the Potomac. These trains attended their corps in the long march from Culpepper to the James river ; and although the roads were frequently very bad, in no instance did they delay the march of the troops, or arrive late when a bridge was to be laid.

The headquarters' train was followed by a canvas train, which, when a crossing was to be made by surprise, was sent forward with the cavalry, who covered the construction of the bridge and held the position until the main body arrived.

On reaching the James river, a bridge was laid opposite Charles City Court House, about 2,000 ft. in length. The water was so deep and rapid that the pontoons could not be held by their own anchors, and it was found necessary to attach their cables to schooners anchored above and below the bridge.

Thus the wooden pontoon-trains, through 4 years of war, during which the bridges constructed were without parallel in number and magnitude, amply fulfilled all the requisites of a good bridge-equipage. The frequent crossing of the Chickahominy, Potomac and James rivers, proved that, even under the most unfavorable circumstances, it could furnish a bridge capable of passing a large army, with its heaviest trains, over wide and rapid streams, with safety and dispatch. Its capabilities in ferrying troops were shown at Ship Point, West Point and Fredericksburg ; and of the mobility of the equipage there was abundant proof in the long marches during the last two years of the war.

The canvas equipage, also, was perfectly successful as an advance-guard train. In the cavalry raids it was always able to keep pace with the columns ; and, although they frequently marched hundreds of miles, it was invariably ready to furnish a prompt and secure means of crossing all the streams on their route. It also often furnished bridges for the heavy trains of the army over streams of moderate width and rapidity.

The only part of the bridge equipage which did not realize the expectations of the engineers, was the Birago trestle. As already remarked, a train was organized early in the war on the Austrian principle, in which the trestle is the main dependence, the pontoon being merely auxiliary. It was supposed that many streams would be encountered which could be bridged best with trestles alone, but none such were met with. In fact, when a stream is more than 2 ft. deep, a pontoon-bridge may be laid ; when less than that depth, if the bottom is hard, it may be forded, and no bridge is required. Should the bottom be soft, the trestle-legs will usually settle, so as to render the bridge

unsafe. As it was not deemed advisable to transport with the army a train which could only be used in exceptional cases, this description of equipage was abandoned. The trestle was, however, very useful as an auxiliary, especially with the canvas train ; for as these boats, when in the bridge, should never be allowed to touch the bottom, it is frequently necessary to build out several buoys from the shore before sufficient depth of water can be obtained to float the pontoon ; and for this purpose nothing could be better than the Birago trestle, which is also equally useful for a similar purpose with the reserve train, where the river bottom is rough near the shore.

The canvas train was extensively used by the Western army, and with such success that it was proposed to employ it exclusively. Experience, however, in the East has clearly proved that this train cannot fulfil all that is required of the bridge equipage of a large army. The bridges of the Potomac and James rivers could not have been built with canvas boats, which will not resist ice and driftwood ; neither are they suited to the disembarkation of troops or the passage of a river by force.

Experience would, therefore, lead us to concur with General Barnard, in his remarks on this subject, namely :—

"The numerous proposers of 'flying' bridges forget that, if a military bridge is intended to be *carried with* an army, it is also intended to *carry* an army, its columns of men, its cavalry, its countless heavy wagons, and its ponderous artillery. It must carry all these, and it must do it with certainty and safety even though a demoralized corps should rush upon it in throngs.

"No make-shift expedients, no 'ingenious' invention not tested by severe experiments, no light affair, of which the chief merit alleged is that it is light, will be likely to do what is required, and what the French pontoon has so often done."

The United States bridge equipage is, therefore, composed of two distinct trains—the reserve and the advance-guard trains. The former are intended to accompany large bodies of troops in the field, and are provided with the materials for the construction of bridges of sufficient capacity to pass large armies, with their heaviest trains, over rivers of any size and capacity. For these, the French pontoon is adapted.

The advance-guard train is intended for the use of light troops, such as advance guards, cavalry expeditions, etc. It is organized both as regards material and carriages, with a view to rapidity of movement. At the same time, it is capable of furnishing a bridge which will fulfil all the requirements of troops engaged in such service. For this train the canvas pontoon is adapted.

The Board have made many improvements in the details of the trains, such as the wagons, tools, materials, etc., submitting every change to the test of actual practice at the Engineer School at Willet's Point. The system of instruction has been also made much more complete than it was heretofore, and it now comprehends all that is necessary for the service of the train, from the elementary drill of the individual pontonier up to the construction of the most elaborate bridge.

The system of instruction is not wholly confined to the construction and management of floating bridges. There is an admirable chapter on the passage of rivers, which contains many valuable expedients for performing this operation, when circumstances render the use of the pontoon-bridge unnecessary or impracticable. There is also a section treating of expedients with insufficient trains ; and, still more important, a complete chapter on the construction of bridges without the bridge equipage.

A ready and intelligent use of expedients is, perhaps, the most valuable quality of mind that a military engineer can possess, and we may justly claim this quality for our people in a most remarkable degree. The record of our military engineers during the war is proof that they are not, like too many military men, bound down by routine, and helpless beyond it, and the presence of such suggestions and such instructions in a drill-book of the Regular army, is still further evidence to this fact.

According to Dr. Cayley, the gold-fields of Khotan are practically inexhaustible, and gold is obtained from them without any great labor or difficulty.

THE DECORATIVE ART OF JAPAN.

From "The Builder."

The glances which we have been enabled to take, from time to time, at the state of art-education in this country, as well as on the continent of Europe, have led to the conviction that, however we may regret the want of due encouragement of the highest forms of art amongst ourselves, we are actually providing a school of decorative and industrial art which has produced much, and which promises more. Leaving aside, therefore, for the moment, the consideration of the great master-principle of the unity of art, and looking at the practical question, how best to stimulate the exertions, and to improve the results, of our actual schools, within the limits to which they are at present restricted, it becomes a matter highly important to the national welfare to inquire in what localities, and to what masters, we are to look for instructive and improving examples of decorative art. We do not doubt that those whose opportunities of study have been such as to acquaint them with the subject, will at once anticipate that we are about to speak of Japan.

It is, indeed, to Greece, in the age of Phidias, that we invariably turn for the noblest examples of the highest forms of art. That this excellence was not confined to plastic art alone, we have the unique, but unquestionable, witness of the "Muse of Cortona," a Greek painting, discovered, comparatively lately, in Italy. In the decoration of the vases of Greece and of Magna Grecia, the historic development of which we may, to a very great extent, trace in the noble collection exhibited in the British Museum, we see rather the exuberance of the art-instinct, as displayed in the work of the potter, than the results of the demand of luxurious taste for sensuous ornamentation. Among the few ancient bronzes in the Italian museums are to be found the *chefs d'œuvre* of all human art. Coins of rare beauty attest the unrivalled excellence of the Greek die-sinkers; and *intaglio*, and even *cameo* gems, such, for example, as those signed by Pyrgoteles, are the masterpieces of an all but extinct mystery of the cunning of relief.

The art of Greece is of that nature of which it is said, with truth, *nascitur, non fit*. While the artist who attempts that which is most noble will ever seek inspiration and instruction from the cradle of genius, any endeavor to reproduce classic forms in their purity, in the present century, is likely to result, as it generally has resulted, in failure. We may spell a certain number of words with a K instead of with a C, without imbibing, by that or by any similar methods, any portion of classic inspiration. The style of the school of David, essentially artificial as it was, is fading from the French academies; in spite of the political reasons which dispose so large a portion of an impulsive nation, toward an imitation of all that was republican in antiquity. The effect of an exclusive study of classic forms—of the second-hand study of nature—in starving the mind, and in impoverishing the hand, is illustrated in a remarkable manner by the works of Flaxman. No artist in modern times had a purer taste, as far as taste could be formed by the love and study of the antique. His power of bold, striking, truthful drawing is evinced by his Italian note-book, full of masterly and admirable sketches of Italian art. Unfortunately, it was the dry bones of the past alone, that this artist found in Italy. He wandered through districts in which, even at this moment, female beauty may be almost called divine, without sketching, so far as his book is evidence, a single exalting model of nymph, or goddess, or virgin. Every scrap of Roman sculpture—poor, ill-drawn, and harsh as these relics often are—had a greater charm for his eye than the lithe forms of the women of Sessa, or the almond eyes of the girls of Lecce or of Brindisi. The natural, necessary result of this indifference to the mundane source of the Greek ideal, is to be seen in most of Flaxman's designs. Of the large number of sketches recently displayed in the Loan Collection at the South Kensington Museum, there was hardly one which an artist acquainted with living Italy (if she can be said to live), would care to copy, or even to possess, except as an autograph.

Admitting, as we must do, that the tone and temper of the day are not such as to allow us to expect the very proximate

introduction, into this country, of the class of art-education which is attempted by more than one Continental Government, it is evident that, in order to make the best of the education actually given, we must not hold too closely to Grecian models. As a mode of instructing both eye and hand in precision of form, and, to a certain extent, as a mode of forming and purifying the taste, the wiser method of copying, alternately, from the antique and from life, which has been introduced into our schools of art, is admirable. In this particular (and probably in this alone) Continental schools may take a lesson from our own ; but so long as our national education is directed to the formation, rather of the art-workman than of the artist proper, we ought to look eastward of Greece for the source of his inspiration. The tendency of the human mind, especially during the time when knowledge is but in the course of acquisition, to mistake *a* principle for *the* principle, is normal and constant ; this evidence of partial and imperfect education is constantly out-cropping in art. It is the origin of most so-called "schools." It erects into distinct academies those minor divisions which ought to be only "forms" in one great, harmonious university of art. It speaks of the conventional, the realistic, and the ideal, as if any true art could exist which did not combine the three. But it is not falling into this vulgar error to insist that the conventional element must preside over the department of decorative art. That point admitted, it follows that examples, invaluable for the use of our industrial schools, may be furnished by the artists of Persia, of China, and of Japan.

It is in the art-works of these countries that we find at once the most perfect treatment of color, as to harmonious blending, and the production of the effect of richness without gaudy vulgarity ; and the most adroit management of geometric or arbitrary form in contrast to the flow and freedom of natural outline.

Japan may be regarded as the locality in which the most valuable discoveries in living art are now to be sought. Its civilization, as peculiar as that of China itself, differs from that of the flowery land, not only in its artistic, but in its historic, characteristics. The most valuable productions of the special craft which takes its name from China, date from the age of the Crusades. The most rare and precious of the various species of Chinese porcelain, fragments of which are now treasured and worn as gems, the azure crackle, was fabricated under a dynasty which ascended the throne more than a century before the Norman Conquest. The most delicate egg-shell china, thin as bamboo paper, was produced early in the 16th century. The rage for cheap production, extending from our shores to the antipodes, has had the same fatal effect on the porcelain of China, that it has had on the iron of England. Modern productions, apparently of "hard paste," are made to sell, and not to endure ; and a collection of valuable porcelain is now as rarely to be met with in China as a chest of good tea—of which herb all but the cheaper qualities have fallen into absolute neglect in those districts which supply the English market.

But in Japan, as far as our limited acquaintance with that unique country extends, no signs are to be traced of decadence in art. Europe is only beginning to awaken to the vigorous life and the remarkable originality of the Japanese artists. It is true that we have long been acquainted with specimens of their rare cunning. The name of Japan, most inappropriately bestowed on the grim black paint, or the shining, splotchy, brown varnish, with which we decorate those iron boxes which are the pride of the legal profession, has been long cited as descriptive of that peculiar lacquer, of which we know little, save of two inferior kinds, the black and the red. Of the ten distinct orders of this peculiar manufacture, ranging as they do, from the gold lacquer, bright in all colors from that of fire to that of the rose itself, through the hues of aventurine and of tortoise-shell, to that vermilion paste (formed of fibres of urticaceous plants, bamboo paper, calcined snail-shells, and oil of camelias), which can be carved and chased like wood, little more than the names are known. Few of us are aware that not only wood, but china and metal, are incrusted with the precious lacquer of the Japanese. Here and there an amateur has picked up one of those rare little cups, Chinese, it may be, or Japanese, in its porcelain lining, the outside of which has been covered by the patient toil of the latter race with a web of wicker, delicate as lace, and firm as if

it were a portion of the earthen fabric itself.

The descriptions of produce which are known to be wrought, with unrivalled excellence, in Japan, include so large a range in industrial art as to suggest how wide a field, and that by no means unoccupied, must lie between. In variety, and in excellence of adaptation for widely different purposes, there are no *papers* like those of Japan. No European silversmith, bronzist, or other worker in metal, can emulate, or can altogether comprehend, the wonderful chasing, inlaying, tinting, and inexplicable transforming of metallic substances, effected by the Japanese metal-workers. Japanese porcelain has a style of its own. Wicker-work and bamboo-work of all kinds are employed, from the walls and roofs of the houses to the outside of the tea-cups. Of lacquer we have spoken. No country of Europe possesses so many specimens of Japanese work as does Great Britain. Her Majesty the Queen has given and has lent, to the South Kensington Museum, valuable specimens of China and of other industrial productions, including most curious grotesque groups in ivory. Up to the close of 1867 the Museum had acquired 183 specimens of Japanese art, of which 40 were carvings in hard wood, ivory, or bone, 20 were specimens of arms and armor, 54 were objects of a textile fabric, and an equal number represented the porcelain of the country.

Japan was not represented at the Paris Exhibition in a manner worthy of her artistic eminence. A few articles of interest, representing the products of the forests of the country, filled a single case. They consisted of fibrous substances, such as palm-leaf sheaths, out of which fine sweeping-brooms are made ; wooden tooth-brushes, charcoal of the tree fern, palm fans, neat wooden boxes, sandals, shields, baskets, and ornamental articles, made from rattan cane, large bamboo stems, and the bark of the *Broussonetia papyrifera* and other trees.

A good collection of samples of paper was also exhibited at Paris. The purposes to which this material is applied by the Japanese are almost inexhaustible. Seventy descriptions are known. They paper their houses, they paper their rooms, they paper themselves ; they have paper tiles, paper greatcoats, and umbrellas of oiled paper ; despatch-boxes, reticules, and tobacco-pouches of a paper imitating leather ; paper-cloth, as strong as leather itself ; card-board, ornamented with gold figures, costing 4 francs per sheet ; gold-spangled and embossed complimentary paper, delicate writing-paper, gelatine paper, wrinkled paper, paper pocket-handkerchiefs, sold at the price of from 4 to 14 centimes per score. It is only necessary for the attention of the Japanese artists to be turned to the subject, for us to be put in possession of lace-paper, suited for ladies' dress, which should unite the richness and delicacy of the finest *point d' Alençon* with an unsullied purity special to itself—the fire being the washerwoman—at an absolutely ridiculous price.

Japanese writing-pencils and cakes of various colored inks are also known in Europe. A case of toys was sent by the Japanese Government to the Paris Exhibition, containing rattles, dolls with movable eyes, dolls of white earthenware with grotesque faces, cups and balls, little boxes of kitchen articles, and similar objects. It was remarked, however, by the English reporter, that, owing to the contents of the case being sold, the guardian obstinately refused to give any information about them.

The peculiar silks with which Japan has lately supplied the European market, are pretty widely known. It is not, however, generally understood that the peculiar hardness and sharpness of these fabrics is due, in some unexplained manner, to the influence of the soil or climate of the island. For when what is called Japanese "seed"—that is to say, the eggs of the silk-moth—is imported into Italy, the descendants of the Oriental insects appear to become *civilized* by the inexplicable charm of the country (or the new food), and spin, after one or two descents, a finer and softer silk.

Of the works of the painters in Japan, we have but few specimens ; but the originality of the canons of art which they follow is no less striking than is the case in other departments. The absence of defined outline is a marked peculiarity. Queer blotches, violent contrasts of color, purposed defiance of what we call symmetry (that is to say, making one side a reflection of the other), distinguish the toil of the Japanese painter, on wood, paper, or porcelain. Yet no one of these

apparently accidental defects can be obliterated without damage to the "barbaric" composition; and the student is forced to admit that there are laws of harmony and of proportion, whether of color or of form, too subtle for his grasp, but of which the Oriental craftsman evinces a perfect and an instinctive mastery.

The wonderful tiger now to be seen at the South Kensington Museum, may be cited as a characteristic specimen of the art of the Japanese painter. It has been previously described in our pages, but is now referred to as an instance of the mode in which nature can be simulated with an art almost equal to her own. Viewed at a distance, innumerable faults may be detected in the drawing, not only of the background, but of the animal. But when viewed closely, even through a magnifying glass, it is difficult to persuade the senses that one is not looking at actual fur.

In treatment of color, an instinct of harmony seems to pervade the Oriental schools, distinct as they are in minor characteristics, which exceeds the utmost skill of the educated European workman. The Indian artists inherit as their birthright, says an English artist and art-writer, a wondrous sense of harmony in tint and dye. In their work we see how gold and color can be brought together; how, through the most marvellous subtlety of color and tint, the greatest sobriety can consist with the greatest richness—richness without a flavor of gaudiness; and, beyond all, how the decoration of each fabric is suited to its use, and thoroughly subordinate thereto. The flat treatment of ornament for textile design, the conventionalized rendering of the graceful forms suggested by, but not blindly copied from, foliage and flowers, and all the varied intricacy of vegetable growth—the production, in short, of so subdued and harmonious an effect, both in form and in color, that the unobtrusive masterpiece of art gives to the eye a rest like that which it experiences in dwelling on the graver aspects of nature—such are the results of the exquisite sensibility to the power, and to the varied refractions of his rays, that the sun has bestowed on his dusky neighbors in the East.

For in this, we conceive, lies the secret of the truth and delicacy of the Oriental taste. East and west are mere comparative terms, accidents of geographical relation; north and south, tropical, subtropical, or temperate, are terms of positive import. Southern Japan, China, India, Persia, Arabia, regard the sun as he shines with a strength unknown in the shifting climate of Northern Europe. The optic nerves, as, indeed, the reasoning powers in general, are stimulated in those lands into a susceptibility unknown to the races who think more keenly than they feel. Repose from glare is the first luxury under vertical sunlight. Thus, by the very glory and brilliancy of his climate, the Oriental artist has been taught how to dip his brush in soft and harmonious hues. The quaint conventional forms into which he has tamed the luxuriance of decorative tracery may, in all probability, be due to the same law. Contrast and consent of color demand duly proportioned areas of display, and appropriate blending of the form and outline of those areas. It is thus that the Oriental patterns have grown out of the Oriental tints. We have this proof that such is the case. In the production of those Oriental people who are so essentially monotheistic in their creed, as to allow no likeness of any living thing to be pictured in their art, we find the patterns which we recognize as Oriental, alone to prevail. Every curve, every line, is conventional. But among those people, also Oriental, whom no religious motive withholds from portraiture or pictorial effort of any kind, side by side with subdued conventional forms, we find the wildest freaks of the grotesque. Michael Angelo never dreamed of such contortions (even in that vision of judgment, in which the chief western painters have allowed themselves the utmost license of anatomical *phantasmagoria*) as are common to the grotesque statuettes of Japan, or the foliated dragons of China. In all that tells of form and of motion alone, the Oriental taste, when unrestricted by the Koran, turns into the very wildest extravagance. The stiffness and reserve of that delineation of form which is made use of, for the express purpose of the harmonious distribution of color, in textile or ceramic fabrics, would therefore seem to have been produced by the instinct of the colorist, rather than by that of the draughtsman.

It is thus to Oriental art that we must

turn, for the best examples to be collected for any school which seeks the improvement of decoration, as an end rather than as an accident. The glories of Saracenic art were, it is possible, at their brightest, when the faith of Islam was yet in the conquering vigor of its youth. India has handed down her art traditions only from a date some two or three centuries antecedent to that of Arabian conquest. Persia had her artists when Babylon was ruled by Persian kings; nor has she lost the instinct of her craft. China, with her written history of 44 centuries, has been, at least in some respects, degenerating and receding for nearly a fourth of that period. Japan, so far as we can tell, has never been more vigorously alive than in her contemporary art. It is to Japan, therefore, that the philosophic student will look for valuable hints, and energetic stimulus, for the decorative artist of today. In metal and in clay, in silk and in other textile fabrics, in lacquer and in wicker, in all that comes under the name of paper, Japan strikes out, in rich profusion, productions which, so far from our being able to equal or to imitate them, often pass our comprehension, when we would inquire how they were produced. Her acrobats and her jugglers; her gymnasts, who hang from the roofs of the loftiest buildings, like monkeys or like birds; her wizard top-spinners, who make that ancient toy simulate the action of obedient intelligence, who give the apparent sportive life of the butterfly to a scrap of paper, and who address an English audience in a whistling dialect, that resembles the spring-tide gabble of our hedge birds, are not her greatest magicians. For her soil is a seat of living, decorative art; and they may best attain to excellence in the pursuit of ornamentation who graduate in that unique university.

The illustrated books which treat on Japan are few. There is an Italian account of the arrival at Rome of some Japanese princes, in the year 1585, printed at Venice in that year. "A Description of the Mighty Kingdoms of Japan and Siam," translated by Capt. Roger Manley, was printed in London in 1683. "Memoirs of the Embassies of the Dutch East India Company to the Emperor of Japan," were published at Amsterdam in 1680. There is a French work, by M. Titsing, illustrating the funeral rites and marriage ceremonies of this strange people, in the latter of which two attendants, called the male and female butterflies, play conspicuous parts. "The Manners and Customs of the Japanese of the Nineteenth Century," and "Japan Opened," are two compilations published in London. "The Capital of the Tycoon," by Sir Rutherford Alcock, is a recent original English work.

But any one who wishes, without visiting the great maritime empire of the Mikado, to form a clear idea of a portion of the human family, amounting to some 35 millions in number, whose elaborate civilization is as foreign to European notions as might be that of the inhabitants of another planet, should read the French work of M. Aimé Humbert, "Le Japon Illustré," which has been published during the present spring. The author, as Envoy Extraordinary and Minister Plenipotentiary of the Swiss Confederation, possessed unique opportunities of making himself acquainted with the interior life of the Japanese. The volumes are illustrated by nearly 500 "views, scenes, types, monuments, and landscapes;" some admirably reproduced from photographs, and some fac-similes of the wonderful drawings of the natives. The writer has regarded his subject rather from the social, than from the artistic, point of view; but many illustrations of the art of this extraordinary race may be found in perusing the work. Without adopting the form of a journal, M. Humbert appears to have written as he travelled; or, at all events, to have taken the outline of his route as that of his work. The result is, in spite of a certain want of system, a more life-like presentation to the imagination of this long-sealed empire than can be readily conceived of without reading the book. The shadowy and mystic dignity of the Mikado, the supreme and sacred sovereign; the rise of the power of the Tycoon, or Taïcoon (High Chief), recalling the history of the Merovingian *Rois Fainéants*, and the Mayors of the Palace; the struggle between the Tycoon and the fierce and powerful feudal princes; the manners of the two-sworded nobility; the sumptuous orgies of Sin Yosiwara, "the City of Vice," grasp the imagination like a fairy tale. A civilization of the utmost polish, free from the influences of either Egypt, Palestine,

Greece, or Rome, is a phenomenon of extreme interest.

The remarks we have made on the subject of Japanese art, and of the more recent literature treating of Japan, were written before the appearance in the English money-market of the Mikado, or supreme head, temporal and ecclesiastical, of that empire, gave to the subject the fresh interest of a topic of the day. In the recent revolution in Japan, of which M. Humbert supplies some of the details, this exalted personage appears to have returned from a condition more closely resembling that of the *fainéant* kings of France, of the Merovingian line, than any more modern parallel. Uniting, to some extent, the functions of Dalai Lama, Pope, and Emperor, this prince has recently suppressed the Siogounate, or vice-royalty, hereditary in the family to the noble known to us as the Tycoon; and, as we have seen, taken the first step towards putting himself on the level of his European brother monarchs—*videlicet*, borrowing money. The amount of a million, ridiculously inadequate as it is towards the execution of any system of railways in the fertile and populous districts of the island empire, would, no doubt, have been immediately forthcoming on the ample security of the customs of the seaport towns. But some people never know when to cry "enough." If our information, which comes from a very central source, be correct, the margin between the price at which the French contractors took the loan themselves and that at which they offered it to the English public was so large (amounting to above 33 per cent.) that, an inkling of the fact having been given, people became unwilling to come in at the tail of such a very long *queue*. Thus we have seen the quotations fall more than 3 per cent. in a single day.

The question will naturally arise, if the Mikado wants English money, why not send it out under the direction of English engineers? The subject is too considerable to discuss in a hurry. One thing, however, is pretty plain from the experience of the few residents who know anything of the inner life of Japan. Foreigners who go to teach these gentlemen (who are, as matter of literature, fully up to our most recent improvements) must be prepared to carry their lives in their hands.

SOLAR HEAT.

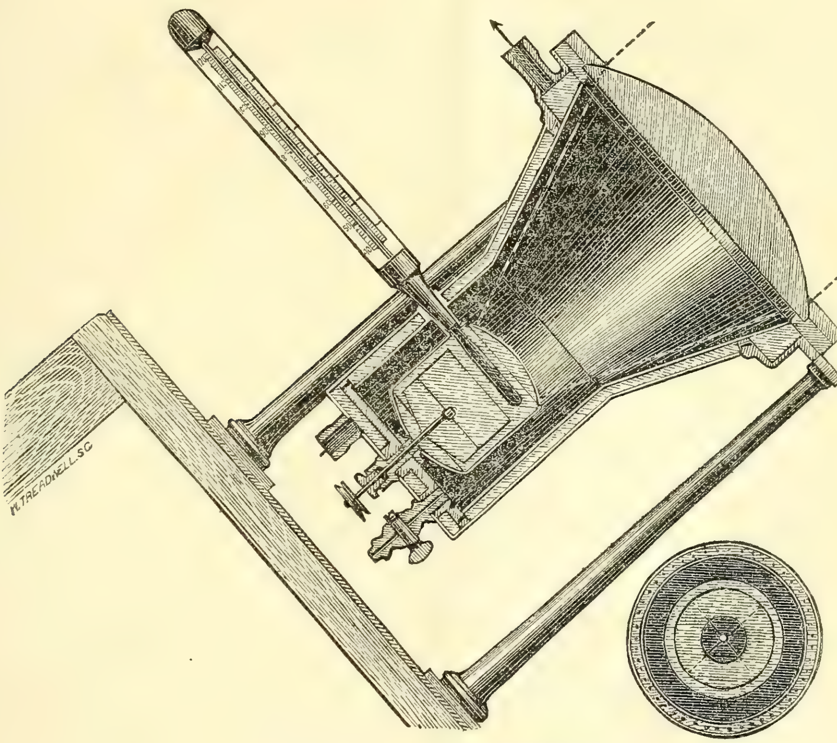
By CAPTAIN JOHN ERICSSON.

From "Engineering."

In a previous communication on this subject, I adverted briefly to some experimental engines which I have constructed in order to ascertain the practicability of employing solar heat as a motive power. I also adverted to the imperfections of the methods adopted by certain physicists to determine the dynamic energy of the sun's radiant heat. Having in the meantime perfected the necessary instruments for measuring, with desirable precision, the dynamic force of solar heat under the varying conditions governed by the changes of altitude, seasons, atmospheric temperature, and the presence of aqueous particles in the air—elements of paramount importance in judging of the applicability of the sun's radiant heat as a motor—I intend to lay before the readers of "Engineering" a series of articles giving a brief account of my researches, to be accompanied by accurate illustrations of the instruments employed.

Apart from ascertaining the dynamic energy of solar radiation by accurately measuring the units of heat developed in a given time under the varying conditions adverted to, I have extended my labors to the determination of the true intensity of the sun's radiant heat. Accordingly, I have instituted a series of observations which enable me to estimate the loss of intensity during the passage of the rays through the atmosphere. By adding this to the ascertained intensity of the radiant heat on reaching the surface of the earth, and before it is affected by terrestrial radiation, I can determine the actual intensity at the point where the rays enter the earth's atmosphere. My attention was originally called to the important subject of actual intensity of solar radia-

tion by reflecting on the limited amount of dynamic energy, about 5 units of heat per minute upon an area of 142 sq. in., exposed perpendicularly to the sun's rays, while the thermometer indicated 150° above Fahrenheit's zero, or 610° above absolute zero. Preliminary experiments, conducted very carefully, having disclosed the startling fact that the real intensity of solar radiation marks a point on the thermometric scale several hundred degrees below the freezing point of water, I resorted to the expedient of concentrating the sun's rays by such a method that the degree of concentration could be accurately measured. Investigations conducted in conformity with this method of determining the true intensity of the radiant heat, proved the temperature to be nearly identical with that shown by the preliminary experiments referred to. The extraordinary fact was accordingly established, that the intensity of the sun's rays before gaining by terrestrial radiation, is



ERICSSON'S SOLAR CALORIMETER.

so feeble that fluid mercury contained in an exhausted shallow vessel covered with a thin lens of about 50 in. focus, and exposed to the full power of a clear sun, will very rapidly become solid—provided the vessel is prevented from receiving heat from surrounding substances. It matters little whether the molecular action within the mass of mercury necessary to keep it in a fluid state is checked by the slower undulations of the solar ray, as waves of a rapid motion are checked by mingling with waves of less motion; or whether the molecular action within the mass of mercury is communicated to the surrounding cold vessel. In either case the reduced molecular force within the freezing mercury proves the inadequacy of the action produced by the sun's rays to maintain the metal in a fluid state.

Incidentally the experiments thus instituted to demonstrate the feeble power of solar radiation before its intensity is augmented by the intervention of the earth's atmosphere have established the fact that the surface of the moon, being devoid of any gaseous envelope, is at all times, even under the vertical sun of the long lunar

day, intensely cold. This apparently irrelevant subject will be considered hereafter. In the meantime, illustrations and descriptions will be presented of the instruments by means of which it has been satisfactorily demonstrated that before the temperature is augmented by the accumulation of heat which results from terrestrial radiation and the presence of the atmosphere, the sun's radiant heat, as before stated, marks a point on the thermometric scale several hundred degrees below the freezing point of water.

Before entering on a description of the accompanying illustration of my solar calorimeter (a denomination adopted in preference to " actimometer," as its object is only that of measuring the amount of heat transferred from the sun to the earth), I deem it proper to say that I object to the inferences which Pouillet, Mayer, and others have drawn from our knowledge of the dynamic force of solar radiation on a given surface of the earth. Unquestionably the amount of heat transferred from the sun to the earth may be accurately computed by means of the solar calorimeter ; but to infer from the point thus established, that the sun parts with as great an amount of heat in *all* directions on an equal area as that which the earth during its orbital motion receives by intercepting and successively arresting the solar wave, is a mere gratuitous assumption. The practical mind refuses to accept a theory which involves such a vast disproportion between the means and the end, as the assumption that 200,000,000 times more heat is wasted than that which is employed to animate the planetary worlds of our system, more especially as the improbable and extravagant, not to say absurd, speculations which have been put forth by Mayer, Helmholtz, and others, all fail to suggest any mode of supplying the assumed enormous waste, which does not point to a speedy extinction of the central force. I will return to this subject on a future occasion, when the consideration of the new motor, the solar engine, will be in order.

M. Pouillet's pyrheliometer being now generally known through Professor Tyndall's work on "Heat as a Mode of Motion," the imperfections of that instrument may be pointed out without minutely describing the method adopted by the French physicist in determining the amount of dynamic force which the earth receives from the sun in a given time. The radical defect of Pouillet's instrument is, that it cannot be used during winter when the thermometer is below the freezing point, as warm water would have to be used, in which case the loss of heat by radiation and convection would be so great as to render the task futile, of accurately measuring the force of solar radiation. This defect of Pouillet's method is the more serious as the heat of the sun is most intense during the winter solstice for given zenith distances, not only on account of the diminished distance between the sun and the earth, but owing to the fact that the sky is clearer on a cold winter's day than during the heat of summer when the air is charged with vapor.

The loss of heat by radiation, in the pyrheliometer ; loss of heat by convection, accelerated by currents of air; the absence of adequate means for circulating the fluid contained within the heater ; the rude method of keeping the instrument perpendicular to the sun with the hand, not to mention the disturbing influence of respiration and the radiation from the operator's body, are self-evident defects. Nor can we pass unnoticed the want of any direct means of ascertaining the depth of the atmosphere through which the radiant heat passes at the moment of measuring its energy. I need scarcely point out that computations based on *latitude, date,* and *exact time,* are too complex and tedious for investigations in which the principal element, the depth of the atmosphere, is continually changing.

It will be well to state at the outset that the solar calorimeter, and all my instruments constructed for investigating the mechanical properties of solar heat, are attached to a table which swings upon a horizontal axle, and which rotates round a vertical pivot, appropriate mechanism being applied for regulating the combined vertical and lateral movement in such a manner that the top of the table, composed of a heavy brass plate accurately faced, is at all times during observations kept perpendicular to the central ray of the sun. Hence, instruments whose base is at right angles to their vertical axis, may be secured at any point of the face of the rotating table, without further ad-

justment. A graduated arc is attached to one end of this table, provided with an immovable index ; consequently, the sun's zenith distance may at all times be ascertained by mere inspection, a very great convenience in an investigation which at every instant is dependent on the changing depth of the atmosphere through which the sun's rays pass. As this depth bears a fixed relation to the sun's zenith distance, it may of course be accurately determined by noting the position of the fixed index on the graduated arc ; but as there is no time during investigations of this kind for computations, as already pointed out, I have constructed a graduated scale provided with a movable radial index, which, by being brought to the division corresponding with the observed zenith distance, shows the depth of atmosphere. It is proper to observe that in constructing this scale I have assumed the earth to be a perfect sphere of 3,956 miles radius. The error resulting from this assumption is, however, so trifling, that the described graphic method of ascertaining the depth of the atmosphere may, without appreciable discrepancy, be employed in all latitudes. The *solar calorimeter* consists of a double vessel, cylindrical at the bottom and conical at the top, an 8 in. lens being inserted at the wide end in the manner shown by the illustration. The interior is lined with burnished silver, and the space between the two vessels is closed at the top and bottom by means of perforated rings, as shown in the transverse section, the object being to distribute equally a current of water to be passed through the space between the vessels. Nozzles are applied at the top and bottom of the external vessel, of suitable form to admit of small hoses being attached. A stopcock with coupling joint is applied at the bottom, communicating with the interior of the calorimeter, and connected with an air pump for exhausting the same. A cylindrical vessel, termed heater, with curved top and bottom, composed of polished silver, is secured in the lower part of the instrument, and provided with a conical nozzle at the top, through which a thermometer is inserted from without. Within the lower part of the heater is introduced a centrifugal paddle wheel, surrounded by a cylindrical casing divided in two compartments by a circular diaphragm, the lower compartment containing four radial wings or paddles, the diaphragm being perforated in the centre. The centrifugal paddle wheel revolves on an axle which passes through a stuffing-box applied at the bottom of the double vessel, the rotary motion being imparted by means of a pulley secured to the lower end of the axle. The operation of this wheel, intended to promote perfect circulation of the fluid within the heater, is quite peculiar. It will be readily understood that by turning the wheel the centrifugal action of the fluid produced by the rotation of the paddles will draw in water downwards through the central perforation of the diaphragm, and force the same into the annular space round the casing of the wheel; thus an upward current will be kept up through this annular space uniform on all sides. This current, after reaching the top of the heater, will then return, first entering the open end of the casing of the wheel, and ultimately the central perforation of the diaphragm. I have been thus particular in describing this system of promoting uniform circulation within the heater because a proper indication of the actual mean temperature of the water contained in the same is the all-important condition on which depends the accuracy of the determination of the number of units of heat developed. It only remains to be pointed out that the lens, which is so proportioned as to admit a sunbeam of 52 sq. in. of section, is placed at such a distance from the heater that when the concentrated rays reach the upper end (painted with lamp-black) they are confined to an area of 3.25 sq. in., precisely $\frac{1}{16}$ of the sectional area of the sunbeam which enters the lens.

It will be obvious that the concentration of the radiant heat on an area of only $\frac{1}{16}$ of that of the section of the sunbeam, removes a very difficult disturbing element from the investigation, viz., the great amount of heat radiated by the blackened surface of the heater, which, in the pyrheliometer, is 16 times greater than in the solar calorimeter. But this is not all; while the 16 times more extensive blackened surface of the former is exposed to currents of air, the disturbing effects of which can neither be controlled nor computed, error arising from convection is wholly removed from the latter, because

the reduced blackened surface of the heater receives the concentrated radiant heat within a vacuum. The loss of heat at the bottom and sides of Pouillet's instrument, caused by convection and currents of air, is likewise wholly removed in the solar calorimeter by the expedient of operating within a vacuum. It will be seen, therefore, that the loss of heat by convection and currents of air has been wholly obviated in the solar calorimeter, while the loss caused by radiation from the blackened surface of the heater has been reduced to a mere fraction. It may be contended, however, that the loss by radiation of the polished heater against the interior polished surface of the calorimeter, although minute, is yet appreciable ; and that some heat will be lost by conduction at the points where the heater joins the external vessel. Even these trifling sources of error, it will be seen presently, have been removed by a new method. A force pump and capacious cistern containing water are arranged near the calorimeter, an uniform temperature of 60° being kept in this cistern by the usual means of a warm and cold water supply. By appropriate hose and the force pump mentioned, a constant current is kept up through the space between the internal and external casings of the instrument ; hence, every part of the latter may be brought to an uniform temperature of 60° in a few minutes. The process of measuring the solar energy is conducted in the following manner : The thermometer being withdrawn, the heater is charged with distilled water of a temperature of about 45°, after which the thermometer is again inserted. The table supporting the instruments should now be turned towards the sun and the paddle-wheel put in motion. The indication of the thermometer must then be watched, and the time accurately noted when the mercurial column marks 50 deg. on the scale, the observation continuing until the thermometer marks 70 deg., at which point the time is again accurately noted. The experiment being then concluded, the table should be turned away from the sun. It scarcely needs explanation, that during the elevation of the temperature of the water from 50 deg. to 60 deg. the instrument radiates *towards the heater*, and that while the temperature rises from 60 deg. to 70 deg., the heater radiates *towards the instrument*. In each case the amount of heat radiated, that is, the gain and the loss, is almost inappreciable, since both the heater and the surrounding internal vessel are composed of polished silver. The amount of gain and loss of heat by *conduction* at the points where the heater joins the surrounding vessel, if appreciable, evidently balance each other in the same manner as the gain and loss by radiation.

The weight of distilled water at 60 deg. contained in the heater, and the weight and specific heat of the materials which compose its parts, being ascertained, the number of units of heat necessary to elevate the whole 20 deg. may be readily calculated. To this must be added the percentage of calorific energy lost during the passage of the sun's rays through the lens. The sum will represent a permanent coefficient for each particular instrument which may ever afterwards be employed to determine the dynamic energy of the sun's radiant heat. Obviously the indication will be equally correct during the winter solstice in a northern latitude with the mercurial column at zero as during the summer solstice within the tropics, when the thermometer marks 100 deg. in the shade.

It must not be supposed that the same difficulty presents itself in ascertaining the loss of calorific energy of the rays of heat as that involved in a determination of the retardation which rays of light suffer during their passage through a lens. In order to determine the former we have only to compare the units of heat developed by the direct action of a sunbeam of a given section, with the number of units developed by another sunbeam of equal section during an equal interval and at the same time, acting through the lens, the retarding influence of which we desire to ascertain. I have constructed an instrument for this purpose by means of which the diminution of the calorific energy of the sun's radiant heat can be accurately measured for all lenses not exceeding $8\frac{1}{2}$ in. diameter. This instrument will be delineated and explained at the proper time.

Referring to the experiments which have been made with the solar calorimeter, it is specially worthy of notice that the sun's energy as shown by this unerring mode of measuring the force actually

transferred to the surface of the earth, is never regular. The force of the radiant heat, call it molecular action, indicated by the increment of the temperature of the fluid in the heater of the instrument, is continually oscillating. At first I attributed this circumstance to invisible masses of light vapor passing through the atmosphere. More recent observations induce me to think that want of constancy in the evolution of the heat at the source may possibly be the true cause.

SUN POWER.

From "Engineering."

Upon another page we publish the first of a series of articles, from the pen of Captain Ericsson, upon the investigation of solar heat, and the means whereby the power so unequally distributed upon our planet can be made useful.

This question, novel and startling as it was when it was first proposed some years since, may now be considered to have assumed a practical form—thanks to the extended and careful experiments conducted by the author of these articles. The result of his experiments, pointing as they do to a means whereby the arid sunburnt portions of the globe are in possession of a vast inexhaustible source of power that may be utilized if science and mechanical skill be properly directed, cannot be overrated. It is idle, now that investigation has proved its possibility, to laugh at the instructor who points out what may be achieved in the immediate future. The fervent heat which to-day pours down upon our tropics, in the remote past bathed our now temperate zones, and, with atmospheric conditions favorable, an immense reservoir of power for future use was stored up. We are drawing now upon those stores hidden by an economical dispensation for wants to come, but a similar heat which was thus concentrated is distributed upon a portion of our planet now, only to destroy and make arid regions which might be placed on an equality with the more fortunate regions could that heat be converted into power, by which the desert would be turned into a garden.

Captain Ericsson has been, and is, laboring to this end, and the result of his experiments, so far, while showing the vast power to be obtained, points out likewise the means to utilize it. Extending through a series of years, his experience has gradually been brought into form, and it is the result of this experience that we shall have pleasure in laying before our readers, in a series of articles, that will contain the substance of an elaborate volume Captain Ericsson proposes, as soon as possible, to publish. But as a long delay will be involved in the production of this book, and as the question is one of too great importance to admit of delay, his investigations will appear in the announced form. In laying them before our readers, we must state, for the benefit of those who are ignorant, and those who know will confirm our assurance, that in the investigation of this question, and the publication of its results, Captain Ericsson has but one object—that of being useful. His life, and long professional career, has been so crowned with honor that he needs no more, and it is simply in the hope and expectation of conferring an universal, almost an immeasurable benefit, and not with any prospective view of fame or profit, that he has taken up and is pursuing these especial labors.

IRON AND STEEL NOTES.

The New Tariff.—We give below the changes made by the new tariff in the duties on Iron, Steel, and Metals, and the manufactures thereof, to go into effect January 1, 1870. Articles of these classes not mentioned remain as before:

On iron in pigs, $7 per ton.

On cast scrap iron of every description, $6 per ton.

On wrought scrap iron of every description, $9 per ton.

Provided, That nothing shall be deemed scrap iron except waste or refuse iron that has been in actual use, and is fit only to be re-manufactured.

On sword blades, 35 per centum *ad valorem*.

On swords, 45 per centum *ad valorem*.

On steel railway bars, 1¼ cent per lb.; and on all railway bars made in part of steel, 1 cent per lb.: *Provided*, That metal cemented, cast, or made from iron by the Bessemer or pneumatic process, of whatever form or description, shall be classed as steel: *Provided*, That round iron in coils, three-sixteenths of an inch or less in diameter, whether

coated with metal or not so coated, and all descriptions of iron wire, and wire of which iron is a component part, not otherwise specifically enumerated and provided for, shall pay the same duty as iron wire, bright, coppered, or tinned: *And Provided further*, That steel, commercially known as crinoline, corset, and hat steel wire, shall pay duty at the rate of 9 cents per lb. and 10 per centum *ad valorem.*

On rough or unfinished grindstones, $1.50 per ton; on finished grindstones, $2 per ton.

On hair pins made of iron wire, 50 per centum *ad valorem.*

On sporting gun wads of all descriptions, 35 per centum *ad valorem.*

On manufactures or articles of nickel, albata, or white metal, argentine, German silver, and the like mixed metals, and of aluminum and its alloys, 45 per centum *ad valorem.*

The following articles, among others, are added to the free list: bells broken and bell metal broken, and fit only to be remanufactured; anthracite coal; emery ore or rock, not pulverized, not ground.—*Iron Age.*

Statistics Relative to Mining in Europe.—The number of furnaces in Europe is about 5,000, of which 1,086 are in Great Britain, 1,177 in Prussia, 926 in France, 481 in Belgium, 436 in Austria, 374 in Russia, 361 in Spain, 255 in Sweden and Norway, 193 in Saxony, 150 in Italy, and 136 in Bavaria.

Of iron the yearly make is about 157,373,000 cwt., of which 91,630,000 is made in Great Britain; 23,560,000, France; 10,521,000, Prussia (old provinces); 8,790,000, Belgium; 7,134,000, Austria. 4,950,000, Russia; 4,150,000, Sweden and Norway; 1,600,000, Italy; 824,000, Spain; 718,000, Bavaria; 617,000, Province of Hanover; 451,000, Saxony; 455,000, Wisbaden; 263,000, Netherlands; 206,000, Wurtemburg; 269,000, Brunswick; 155,000, Cassel; 139,000, Hesse; 120,000, Portugal; 101,000, Baden; 20,000, Denmark; and 20,000, Greece.

The worth of the total produce of iron in Europe amounts to about 966,000,000 fr. (it exceeds in worth all the remaining metals by nearly three times); of this amount Great Britain makes 412,000,000 fr.; France 197,000,000; Prussia, 80,000,000; Belgium, 80,000,000; Austria, 55,000,000, Sweden and Norway, 45,000,000, Russia, 41,000,000; Italy, 14,000,000; Spain, 8,000,000; Switzerland, 3,500,000; Netherlands, 200,000; and of the rest of Europe, about 3,500,000 fr.

By this valuation the worth of 1 cwt. of iron in Sweden and Norway is 10 fr. 80c.; Switzerland, 10 fr.; Spain, 9 fr. 70c.; Belgium, 9 fr.; Italy, 8 fr. 70c.; France, 8 fr. 50c.; Russia, 8 fr.; Austria, 7 fr. 70c.; Prussia, 7 fr. 60c.; in Great Britain, 4 fr. 50c.—*Bulletin of the American Iron and Steel Association.*

The "Waste" at our Ironworks.—Economic iron making is of very recent growth. Those who have examined old mounds near the site of the earliest ironworks are astonished at the waste shown in carrying out the primitive details of extracting iron from mine stone, a much larger percentage of iron remaining in the refuse than was extracted. This was notably the case with the Romans. At Cinderford and other places on the borders of Wales the "cinders" have proved of great value, and all are well nigh utilized. This waste was not confined to the Romans. We have examined cinders from old workings dating from the time when the Sussex ironmaster migrated into Wales, and also at the remains of furnaces placed by Mushet and others, as far back as the Elizabethan era, and the same fact is observable. The means then employed were rude and inefficient, and, coupled with this, there was an evident haste in the arrangements, the desire being to obtain as much metal as it was possible to gain in the least amount of time. Coming down to a later period, we find, in the early annals of the Plymouth Works, that the refuse cast aside, and made into tips, contained 40 and sometimes 50 per cent. of iron. Until Mr. Anthony Hill's patent this remained unworked, but thanks to him, the method of working it was discovered, and the huge tips were soon levelled and used up.

Penydarran Works, more than any in modern times, still retain amongst its ruins—now, we are glad to state, in progress of re-establishment—the evidences of great, we might almost say wilful, waste. Started at a time when iron making was most profitable, little details of economy were overlooked, iron mine was abundant; wood, and after that coal, equally so. As long as ironmasters found immense returns coming in they were content, and thus, while colossal fortunes were being made, many small ones were lost in absolute waste. A laughable incident of this has been related to us of Alderman Thompson, when part owner of Penydarran. He had his attention called to the looseness shown in the works, and was accustomed on every visit to bewail his fate, and say he should be ruined. One day he gathered some nails scattered on the ground, and repeated his doleful cry: "This shocking waste! I shall be ruined." As he was saying this he entered John Rees' lodge. John, who was a bard as well as a workman, finding himself lazily inclined, perhaps in a poetic mood, felt disinclined to go to the coal heap to replenish his fire, and was occupied in raking up the cinders with his hands. "Ah!" exclaimed the Alderman, "here's a careful man at last!" and ever after regarded him with favor.

At these works, and on the whole estate connected, we have evidence of the most wilful waste. The iron—and always the best—used in the building was something enormous; where slate and wood, or stone, would have done better. Sheet iron was brought into requisition. The supply of coke to the blast furnaces, containing even a greater percentage of iron than the "waste" which Anthony Hill found so valuable.

The estate, extending over several miles, still retains the old sign of extravagance. At the bottom of long-disused tips, weighty iron trams—now rusted and decayed—remain, left there years ago by men too lazy to pull them up. You come to a cottage by the side of a little stream, and a fine piece of sheet iron has been improvised into a bridge. Old rails fence off the approach of another, or are made into a "stile." At the top of an incline, massive slabs of iron remain in profusion, cast aside as so much rubbish, and almost concealed by earth and weeds. And you have only to remove a little of the tips to find iron nodules abundant enough to make the mounds so many valuable "mines" to the enterprising ironmaster. When we see these evidences—so abundant among us now—we have a good idea afforded of the waste that was exercised in the daily round by the workmen. It is a fact that numbers of men at Penydarran fifty

years ago earned £20 a month; another fact, that the puddlers kept a keg of rum on tap on the works, and that the earnings were squandered profusely. Such men, neglectful of their own means, would pay less regard to the interests of their employers, and scatter his means with the freest hand. Of late years this has been corrected to a great extent. There is a methodic manner now observed, in strong contrast to the past. Lime, coke, and limestone, are weighed carefully; every ounce is economized, and the results—pig and rail, or bar—brought under the same arithmetical precision. Coal, too, once used in profusion, is now economized; and this is seen forcibly at Dowlais. Formerly the largest and best coals were used, while small coal was cast aside as worthless. Now, by the discovery of the use of waste gases from the blast furnace, the small coal is made to do duty instead of the other, and the large and best coal is sold in great quantities. We have little hesitation in stating that within the last 10 years the Dowlais coal-fields have been made to form no inconsiderable source of revenue to the proprietors. This is a step in the right direction, and though much waste still continues in the various ironworks and steelworks, the subject is now under thoughtful scrutiny, and we may hope to see the loss reduced every year.—*The Engineer.*

From Sheffield, England, our latest advices say: The demand for steel, both at home and abroad, continues brisk, and more is now being sent to America than for many months past. It is feared, however, that we have not yet heard the last of what was so long known as "the steel difficulty," despite the recent decision of the General Appraiser in New York as to the correctness of our manufacturers' invoices. The demand for Bessemer steel rails, and for railway material generally, is exceedingly brisk; and so great and many are the orders for rails that Bessemer steel is being sent to Sheffield to keep pace with the demand. The armor-plate mills are well employed, though this department is scarcely as active as it was, and the same remark applies to the rolling-mills. There are but few heavy castings in hand. The file trade has recently become increasingly active, but as yet the orders are not sufficient to find employment for the whole of the workmen, some of whom continue to work on short time. The saw trade, also, which has been depressed for many months, has of late been improving, but at present there is nothing like briskness, and it is to be feared that the welcome change which this branch is now experiencing will be only of a temporary and partial character. Some good orders are in hand for several descriptions of edge-tools.—*Bulletin of the American Iron and Steel Association.*

Improved Blast-furnace.—Messrs. J. and G. Onions, of Dudley Port, have recently completed the erection of a blast-furnace, designed to effect the consumption of the waste gases, after the manner of those in the Cleveland iron district. The furnace was commenced in January, and was put into operation ten days ago. It is of much larger dimensions than those ordinarily in use in the Black Country, being 50 ft. high, and 13 ft. 6 in. in diameter at the bosh. The mouth is closed, but 2 massive tubes carry the smoke and flame to the hot-air apparatus and the boiler respectively. By this plan the saving of fuel and labor is, of course, very considerable. Mr. Onions estimates the saving of slack at 120 tons per week, of the aggregate value of £30. The following laborers are also dispensed with—four firers, four boat-unloaders, one bridge-stacker, one coal-wheeler, and one ashes-wheeler. There is no escape of smoke whatever, and the furnace contrasts strangely with those around it, each of which is polluting the air with sooty volumes by day and night. We noticed 7 tuyeres on the furnace; ordinary furnaces have 5. By having the greater number, however, a more equal distribution of the blast is effected. The furnace is now producing all No. 1 gray iron, for melting purposes, but it is intended ultimately to confine its produce to forge-iron. The present rate of production is 180 tons per week, being nearly double that of the old-fashioned Black Country furnaces. The cost of the new furnace, in erection and plant, is about £2,000 more than those on the old principle. The contiguous buildings are all on a complete and substantial scale. The stack is 150 ft. high, 9 ft. clear inside at the top, and has a base of 16 ft. sq. The design is entirely by Mr. Onions, and it infringes no patent right whatever. Many of the principal ironmasters in the district have been to see the furnace in operation, and express themselves satisfied with its success.—*London Mining Journal.*

The number of tons of railroad iron rolled in this country during the last four years was as follows:

1866	430,766	1868	516,000
1867	462,108	1869	580,000

The Pennsylvania Steel Works, for the manufacture of Bessemer steel rails, at Baldwin, 3 miles below Harrisburg, are the largest of the kind in the United States. The Bessemer Building is 114 ft. long by 100 ft. wide and 25 ft. high. The adjoining building is 80 ft. long by 52 ft. wide and 39 ft. high. The engine and boiler building is 133 ft. long by 52 ft. wide and 15 ft. high, besides a blowing engine room 66 ft. by 22 ft. The buildings are of blue limestone, roofed with slate.

RAILWAY NOTES.

The Westinghouse Atmospheric Brake.—This brake, the invention of Mr. George Westinghouse, of Pittsburgh, has passed the experimental stage. In the judgment of the managers of the most of our leading Western, and of a few of the Eastern lines, it is regarded as a decisive solution of that most difficult of all operating problems—the sudden stopping of the heaviest possible train at the highest speed without inconvenience to passengers, and with no appreciable injury to machinery. When a short train, too, going at high speed can be brought to a rest in running its own length, the limits of the practicable would seem to be attained.

The record of the tests to which Mr. Westinghouse has submitted his brake is familiar to the readers of the "Review,"—as is also the description of the device—full particulars having been given, especially in our issues of October 7th and December 2d, 1869.

The purpose in the present article is, not to recount these, but to state the facts concerning its

introduction, and to give a summary of the excellencies which all our managers who have adopted it unite in ascribing to it. The number of engines and cars to which the apparatus has been applied is shown in the following :

	Engines	Cars.
Pennsylvania Central	50	200
Pittsburgh, Fort Wayne & Chicago	10	30
Chicago & Northwestern	2	11
Chicago, Burlington & Quincy	8	20
Chicago, Rock Island & Pacific	2	6
Union Pacific	19	50
Michigan Central	10	25
Jefferson, Madison & Ind.	2	13

The Pan Handle and Lake Shore and Michigan Southern are running each one train. We have conversed, personally, with the most of the managers of the roads above named, and the following is a statement of the conclusions to which we have come :

1. Many devices, theoretically sound, fail to realize the expectations of the inventor from the fact that too little "margin" has been left in a complicated apparatus for wear and tear. Necessary repairs must neither "cost more than they come to" in money ; nor must they too frequently or too long withdraw the apparatus from service. Its working parts identical with those of the locomotive, attached to the existing brakes of the car which it works by the most simple and durable apparatus—the Westinghouse brake perfectly meets the requirements of every-day trains. In fact, we speak advisedly when we say that its use involves less wear and tear than that of any other equally important portion of the machinery of the train. The maximum speed of the air-pump piston attached to the engine is but 100 ft. per minute ; the piston under the car, working but once at each stop, practically, can never wear out ; the hose—heavy india-rubber—slack between the cars, exhibits no signs of wear in cases where it has been used a year and a half ; while its couplings—which are automatic, leaving the brake applied even to a detached car—are so simple and so strong that they cannot be injured except by heavy hammering.

2. It secures instant application of the brakes to every wheel of the longest train, the pressure on all the wheels being "elastic" and uniform. Under the control of the engineer, the force with which it is applied can be graduated from zero to the full power. So that not only can a train at high speed be instantly arrested, but slacking of speed can be accomplished on down grade, at bridges, etc.—just the amount necessary, the train being held at any given speed, fast or slow.

3. There is, thus, no superfluous expenditure of force, and no unnecessary wear and tear. The uniformity and steadiness with which the brake is held prevents the wearing of "flat spots" in the wheel—which under the old system sometimes ruins a wheel in a single trip ; all sliding of the wheels is done away with ; the safety of the train in making frequent stops is not only insured, but the making of running time is secured, and the comfort of the passengers is greatly increased, as the application of the brakes is never heard or felt.

4. The advantages of a system by which the engineer, with the same act by which he now whistles "down brakes," can himself stop the train, although obvious, may be here suggested in the light of results. At from 30 to 40 miles per hour a train runs at a speed of about one car length per second ; and this brake would bring it to a rest in 6 car lengths. On the Pan Handle line, about 5 weeks ago, the train was approaching the station at Burgettstown, when the engineer discovered the rear end of a freight train 300 ft. ahead. Running at the rate of 25 miles per hour on a down grade of 58 ft., he applied the brake and stopped his engine within 25 ft. of the train. In another instance, going around a curve on a down grade, a man was observed on a trestle ahead, and his life saved. The instances in which live stock on the track are saved, and accidents to the train at the same time avoided, have been very numerous. In one word—this brake is liable at any moment to be the means of saving life ; while the security of property (saying nothing about diminished wear and tear to the train) which it affords must pay for its introduction many times over on any great road.

5. Finally, the apparatus is so identical in principle with the machinery of the locomotive that it can be applied, in a very short time, to *any* engine. As we have stated, it works in connection with the hand brakes—as also *with the Miller platform.* The charge for fitting a train with it is :

Locomotive	$300
Tender	25
Per car	100

Shops for manufacture and repair have been erected at Pittsburgh. The Company have already turned out $70,000 worth of work ; have $100,000 more (on order) in hand ; and are ready to fill all orders promptly. All the parts of the apparatus are made on uniform pattern, so that duplicates of any piece can be at once obtained.—*Chicago Railway Review.*

Improved Bogie Engines and Elastic Self-Adjusting Railway Carriage Wheels.—Mr. George Smith, M. Inst. C. E., of Belfast, has just introduced to the public some improvements in bogie engines, which consist of an arrangement of segmental-headed pins or bolts attached to framings of the engine and bogie, and so constructed as to allow of a true motion round the centre, and admitting also of a compound transverse and circular motion, by means of slots made in the slides. The engine, carriage, and bogie frames are always in contact, and sliding upon each other. The weight is equally distributed amongst the wheels of the bogie by means of a system of compensating levers connected to the springs.

The novelty of these wheels consists in the body, hoops, spokes, or discs being suspended to the tyres. By such an arrangement the tyres are in compression as well as the body, spokes, or discs, while the hoop is always in tension ; the reverse in principle to the constructions at present adopted.

The advantages are cheapness, lightness, durability, greater safety to the trains, especially at high speeds, as the tyres cannot separate or break from the body, hoops, spokes, or discs of the wheels; nor can they mount the rails. As the tyre shears instead of biting, there are less jolts, less tear and wear to engines or carriages, and permanent way ; no skidding or sliding or lateral concussions, nor any necessity for double rails at sharp curves. The improvement also prevents torsion to cranks and axles. As the tyres regulate themselves to the irregularities of the permanent way, there will be

less straining or vibration of the bridges on account of the elasticity of these wheels. Lastly, it is found that with these wheels in use, there is no need to loosen the ballast, as is often done, to give elasticity to the rails, so as to lessen the hammering of the rigid wheels as at present constructed. The jolts and jars now felt in going over loose joints of the rails, and especially on bad, rigid, or frozen roads, are greatly, if not entirely prevented (a boon to passengers, especially in long journeys). The arrangement also enhances the safety of the body's spokes, or discs of the wheels, whether made of wrought or cast iron; as they are loosely suspended in elastic steel or iron hoops, they may expand or contract without strain or contortion to the several parts, under all changes of temperature, whereas in the tyre and body of the old wheel there is a constant danger, in consequence of their unequal expansion and contraction, more particularly in sudden changes of the weather. These improvements are obtained by suspending the axle from the top of the wheel by means of an elastic steel or iron hoop, which allows for any inequality in the rails, while at the same time the tyre is free to revolve independently of the body of the wheel.

The disadvantages or defects of the present wheels are their tendency to mount the rails, and their liability to sliding and lateral concussions, thereby occasioning oscillations of the train, matters which not only engineers but ordinary railway passengers cannot fail to have observed; but, beyond these defects, and not so obvious to the uninitiated, are loss of power in traction by the unequal wear and tear of the tyres; also unequal expansion and contraction of the tyres and body, torsion of the cranks and axles; and these defects are greatly increased should the frames of the engine or carriages get out of the square by twisting or straining, leaving out of the question bad roads, unequal lengths of the rails at the various curves, all of which have to be taken into consideration, independently of the straining and vibration of the bridges when passing over, as well as the enlargement of the engine tyres, when they have to be taken off and re-set. There is also the ever-present danger of the tyres, when at high speed, separating or breaking from the body of the wheel, to the destruction of the train, and danger of life, all owing to their being fixed on the axles.

The object of the self-adjusting, elastic, or suspended wheels is to obviate the above-mentioned disadvantages or defects of the fixed wheels now in use, to obtain which is to have the elasticity as close as possible to the working-point between the wheel and the rail, as all unnecessary weight interposed between the axle and the rail is adding inertia, thereby increasing the wear and tear of the wheels and rails.

THE ARMSTRONG STEEL FROG.—"The Chicago Railway Review" says: It is claimed that the usual steel frog cast in mould is open to objections,—that, during sudden changes in temperature or when subjected to severe concussion or heavy weights it oftentimes breaks, and from the necessarily brittle nature of the casting is liable to chip and flake under ordinary wear; and that it is at the same time extremely unyielding and rigid—characteristics which are by many experienced engineers considered elements of much danger when trains pass over them at great speed.

In the forged steel frog of Messrs. Armstrong, it is sought to avoid these objections. The metal, from being hammered, becomes fibrous instead of granular, giving a strength and toughness which render it impossible for the frog to be broken or to chip in wearing. Moreover, this process gives to the frog the nature of a spring, doing away with the rigidity often felt in running.

The arrangement for fishing the frog—at both its ends—to the track rails would seem to be a vast improvement on that of slotting the rails usually employed. This fishing of the frog is very highly esteemed in Europe; indeed there is not a frog laid in any railroad line that has not the fish bar fastening applied. Messrs. Armstrong & Co. desire us to state that they specially guarantee that this frog shall endure double the ordinary wear and tear—or more specifically, that it shall wear for *ten years, with* 80 *trains a day passing over it.*

We hear that this invention is meeting with a very extended sale in all parts of the United States. Our railway engineers are seldom slow to acknowledge and adopt meritorious inventions whenever a wise and prudent economy or advantage can be gained thereby.

WE stated a short time since that the plan patented by Mr. Bessemer for preventing sea sickness by constructing a chamber for passengers on board steamers suspended, on the same principle as the compass, was about to be practically tested, and that Messrs. Maud lay were constructing a screw steamer of 300 tons burden upon the principle. We understand that the steamer will be ready for its trial trip in November next. Should the result equal the anticipations of its inventor, and of all who have seen the models and drawings, it must lead to the construction of similar ships capable of taking all the traffic between this country and Europe. Two of these, it is calculated, could be built for £130,000, of great size, fitted with the most luxurious accommodation, and of sufficient power to make the Channel passage in 60 or 70 minutes. In the event of the process being found perfect, Mr. Bessemer intends, we believe, to offer the use of it first to the various interests primarily concerned, such as the English continental railway lines, etc., and, failing any arrangement with these, to organize a general system of international communication with independent capital. As respects the future prospects of the railroads in connection with Ireland on the one hand, or the Continent on the other, the importance of the approaching trial can hardly be overestimated.—*Railway News.*

ORDNANCE AND NAVAL NOTES.

THE FRENCH "MITRAILLEUSE."—To destroy your enemy in the shortest time, in the easiest manner, and at the least possible expense, is the first maxim of war. The stone that whistled from David's sling, the bullet of the "zundnadelgewehr," and the volley of the "machine gun" had all the same object. Since the days of Roger Bacon the aim of all improvements in fire-arms has been to carry the greatest possible number of deaths to the greatest possible distance. Grape, canister or case, and shrapnel, all contain bullets, and are all means for multiplying deaths. The field-gun mows down its hundreds by showers of case at close quarters, or at longer distances rains bullets from the bursting shrapnel. The mitrailleur, or

machine gun, on the contrary, sends a large number of small projectiles independently, and with precision, to a considerable distance. We may divide arms on the latter principle into two classes —1st, those which discharge their bullets from a single barrel, fed by a many-chambered breech; and, 2dly, those in which each cartridge has its corresponding barrel, the charging and discharging of which is direct, and more or less simple. It is obvious that for rough usage and continuous firing it is better that a large number of rounds should be fired from a considerable number of barrels so placed as to support each other and add strength to the whole machine. The French Mitrailleuse, as well as the Belgian Montigny, belongs to the second class, and the following brief description is equally applicable to both arms:— "The machine-gun consists of a cluster of barrels either bound together or bored out of the solid, and mounted on the same principle as an ordinary field-gun. At a few hundred yards, indeed, it would be difficult to distinguish between these weapons as far as outward appearance goes. To the barrel is attached a massive breech action, capable of being opened and closed by a lever. In the Montigny arm the cartridges are carried in steel plates, perforated with holes corresponding in number and position to the holes in the barrel. This steel plate, in fact, forms the "vent piece" of the system. The central-fire cartridges being dropped into the holes in the steel plate, stand out at right angles from it, and the plates, thus ready charged, are so carried in limber and axletree boxes specially fitted for their reception. When the gun comes into action the breech is drawn back, a steel plate full of cartridges is dropped into its corresponding slot, and the breech block thrust forward and secured. The gun is now on full-cock, and contains from 30 to 40 cartridges, which are fired by a "barrel organ" handle, either one by one as the handle works round click-click, or in a volley by a rapid turn of the wrist. When the gun is empty, the breech block is again withdrawn, the steel plate carrying the empty cartridge cases lifted out, and a fresh plate dropped in, if necessary. The advantage possessed by the machine-gun over infantry fire is that it is never in a funk. Bullets may rain around, bursting shells may fill the air, still the 37 barrels of the Mitrailleuse shoot like one man, and at 800 or 1,000 yards will pour volley after volley of deadly concentrated fire into a circle of from 10 ft. to 12 ft. in diameter. No boring or fixing of fuses is required, and the whole operation is performed so rapidly that two steady, cool men could maintain a fire of 10 discharges per minute. On the other hand, the Mitrailleuse could not well compete with the field-gun, and it is with this weapon it will assuredly be met. Its bullets would have comparatively slight effect at the ranges at which field artillery projectiles are perhaps most effective, while its size would offer a very fair mark to the gunner. The foreign press are welcome to write *fanfaronnades* about the sudden death of wretched horses at incredible distances. This is peace practice. The horses came from the knacker's yard, not from the banks of the Elbe, and there were no Uhlans sitting on them. We are also tempted on such occasions to take the square root of the reported distance as the actual range. The future of the Mitrailleuse, however, depends on coming facts. The day's experiments are over; there are hundreds of machine-guns trundling towards the Rhine. The drum-like roll of their volleys may ere long be heard in the vineyard of Rudesheim, or on the edge of the Black Forest; and the "thud" of the bullet may come from something softer than a wooden target. Yes, the machine-gun is *en route* for the Rhine; the experiments will now be on a gigantic scale; and Mr. Cardwell may adjourn his special committee, until after Christmas at any rate. By that time the voice of war will have given the verdict; by that time the Chassepot, the Zundnadelgewehr, the shrapnel, and the volley-gun will each be credited with a ghastly account, and we shall know which engine destroys human life in the shortest time, the easiest manner, and at the least possible expense. —*Globe.*

International Communication.—Mr. Bessemer supplies the following description of his invention for improving steam communication by the construction of a suspended chamber. He says:

"The experimental vessel is of only 153 tons measurement, and although much too small to attain the best results, is, nevertheless, quite large enough to make the Channel passage, and prove beyond question the practicability, or otherwise, of the mechanical principle involved. Not the least of the advantages which the new system of ocean transit offers is the shortness of the time and the small amount of capital required to put it into operation at every seaport in the kingdom. For instance, two steamers, fitted with means for the most luxurious accommodation of passengers, in vessels of great size, and having sufficient engine power to cross the Channel in 60 to 65 min., and fully adequate to carry the entire passenger traffic, could be put on the station within eight or nine months from the date of order, at a cost not exceeding £130,000. The commercial advantages of such a system, as compared with those proposals which would require some £8,000,000 or £10,000,000 sterling, and several years to execute, will be readily appreciated by the public, the more so as my system will be subjected to the test of actual trial before a shilling need be expended by the public upon it. The proposed new system does not contemplate the employment of ships that shall be motionless except in the direction of their course, for the waves would strike on such a vessel as on a rock, and dash themselves over her as they sometimes leap the Eddystone. It does not attempt to arrive at the end desired simply by construction of ships or rafts of vast size, for it is well known that the largest ships that have ever been built roll frightfully in the Channel in bad weather; nor is it by any new and untried external form of the vessel, involving new problems in navigation; on the contrary, my system in no way whatever interferes with the external form or with the sailing qualities and safety of the vessel, the whole difference being in the internal arrangements of the ship, and is based on the well-known law that all bodies which revolve or roll, in so doing move about a centre where there is no motion, and all beams that vibrate move also about a centre, from which point the distance moved through by any part of the beam is as the distance from this central point. Now, therefore, if we make the centres about which the vessel pitches and rolls coincident with the axes on which the saloon is suspended by suitable mechanism, and provided with a heavy counterbalance weight beneath the centre of gravity, the tendency of this weight will be at all

times to keep the saloon poised on the centre of the vessel's motion, and therefore free from pitching or rolling, its floor remaining always quiet and horizontal, while the vessel itself may be pitching and rolling about the centre of suspension. The most convenient form for such a saloon is circular, surmounted by a large dome, lighted at the top with glass. It is proposed to make this circular saloon of 50 ft. in diameter, and 28 ft. in height internally, having a gallery extending entirely around its interior at about 9 ft. from the floor. A continuous couch around this gallery would accommodate 60 persons, while about 70 others would find a similar accommodation below, independently of the large space afforded by the floor of the saloon. This large and lofty apartment, although much smaller, would present somewhat the general appearance of the new reading room at the British Museum. It would be supplied with plenty of cool, fresh air, from below, which would pass off through the glass louvres in the dome ; the saloon would be entirely separated from the rest of the vessel by water-tight bulkheads, thus cutting off all unpleasant smells from the engines and boilers. The suspension is so arranged that the vibration of the engines and propeller cannot be transmitted to the saloon, which is also relieved from the constant thud of the waves striking against the sides of the vessel, because there is no contact between the ship's sides and the walls of the saloon. Suitable ante-rooms leading from the saloon are also provided for invalids, etc. The general plan also embraces the construction of raised deck platforms, so arranged that those who prefer the open air may have beneath them a steady platform free from the rolling and pitching motion of the vessel.

" From the cursory view here given of the mode in which I prose to secure at all times a perfectly steady platform on board ship, the scientific reader will doubtless see many grave difficulties. He will probably ask : How do you propose that passengers shall pass from the reeling deck backward and forward at all times into your quiet immovable saloon ; how can you prevent a pendulous motion of the saloon from being set up by the variation in position of the centre, which will occur unless your vessel rolls and pitches at all times actually on a point conincident with the point where you have established your centre of suspension ? How can you prevent the saloon from being put in motion by people moving in it from side to side ? My reply to these anticipated queries is simply that each of them and many others besides have been presented to my mind in full force during the elaboration of my plans, and each has been so fully met and provided for as to offer not the slightest obstacle to that success which I believe my little ship, the Enterprise, will fully establish when put to sea, until which time I must beg the critic to suspend his judgment."—*The Railway News.*

THE CHASSEPOT AND THE NEEDLE GUN.—Some account is published in the " Birmingham Gazette " of Monday of the two weapons which are in the hands of the belligerents on the Continent. The " Zundnadelgewehr " or needle-gun of the Prussian service, to which the victories of the Prussian arms in 1866 have been attributed, appears to have been originally patented in England as a muzzle-loader in 1831, by a Mr. Moser, of Kennington. The invention came before its time. Its cold reception in England drove the patentee to seek foreign patronage for his novelty, and Prussia was lucky enough to appreciate and to adopt the new weapon. Dreysa, a gunmaker of Sommaler, applied the breech-loading principle to Moser's patent, and thus amended, the arm ten years later was in 1848 introduced into the Prussian service. The principle, briefly stated, is the driving of a pointed piston or "needle," by the action of a spiral spring (such as is used in the manufacture of children's toy guns) into a small case of fulminate, contained in and situated between the powder and the bullet of a single cartridge. In the action of opening the breech, the spiral spring is set by the trigger, and thus the trigger, when pulled, releases into operation the spiral spring, which, in its turn, forces the needle into the cartridge, and fires the piece. Upon this oldest form of the Prussian needle-gun improvements have been made, the chief effects of which have been a reduction of the mechanism of the needle of 1848, and a general lightening of the entire piece. None of these alterations, however, have touched those two apparent evils in the whole form of this arm which militated against its adoption by England in 1850. These are the positions of the fulminate in the interior of the cartridge and the looseness of mechanism, involving possibility of the escape of gas round the needle and at the base of the plunger. To these two particular points France mainly devoted herself in seeking a superior needle rifle to that of Prussia. In the Chassepot such an improved arm has been found. A triple wad of vulcanized india-rubber placed round the axis of its plunger, and with a steel plate a cushion to receive the force of the rebound, is intended to render the breech gas-tight, but has been found in practice only partially adapted to that object. An ingenious arrangement of notches on the outer girder of iron, before described, enables the gun to be placed at half-cock. The needle is lighter and smaller than in the Prussian gun, and, above all, the cartridge contains its fulminate at the base of the powder, instead of at the base of the bullet. A vacuum, left when the gun is charged, between the base of the cartridge and the front of the plunger, is intended to effect the combustion and removal of any portion of the cartridge-case that may remain after firing. As compared with the Prussian gun, this weapon possesses, besides the specific improvements mentioned, other advantages of superior manufacture and finish. Its cartridge, besides admitting the altogether different principle of firing contains a larger charge of powder than the Prussian cartridge, with a smaller bullet, which leaves a manifest advantage in carrying to the French weapon ; while the fact that the Prussian bullet is purposely made so small as not to touch the barrel in its passage, while the French bullet is of the ordinary size to fit the rifle barrel, would point to the conclusion that the Prussian marksman is at a disadvantage over the Frenchman in respect to his aim. The number of times of firing per minute is about the same in both cases. The cost of the French weapon considerably exceeds that of the Prussian, and the Chassepot is, in addition, a more difficult gun to make. To all the comparative information which has been published about the French and Prussian guns must be added the following from the "Journal du Peuple" :—"At 500 metres the Prussian weapon gives only negative results, while at 1,000 the Chassepot, in the hands of good marksmen, hits the target with great force. We

call attention to this point, for in the war of large bodies of sharpshooters (the only system which we ought to adopt), an arm which is not reliable over 500 metres cannot reach the reserves of the first front, which escapes the effect of the enemy's fire. The drawbacks of large bullets have been noticed, the principal being this, that with needle-guns, the firing is rapid, and, therefore, a great amount of powder is burnt; consequently, the cartridge-box must be well stored. Now, there is in the weight of ammunition allotted to a foot soldier a total which cannot be exceeded, namely, 10 lbs. What will happen? With that weight of cartridges, the Frenchman will have twice as many shots to fire as the Prussian. Nothing is more difficult than to replace during fire the ammunition by a fresh distribution. Thus, the retreat of a division may depend on its finding itself in face of an enemy which has still twenty or thirty cartridges a head to fire. It will be seen that the winning of a battle may depend on the projectile adopted."—*Globe.*

An extremely satisfactory result, as far as the navy is concerned, was lately obtained at Shoeburyness. A target representing a portion of the deck of an iron-clad ship, protected by 1-in. iron plates, was fired at by the 9-in. muzzle-loading rifled gun, the projectile being Palliser shell, the charge the full battering one of 43 lbs., and the distance 100 yards. The target was so arranged that the projectile struck at an angle of about 8 deg. from the horizontal, so as to represent the angle of incidence of a shot fired direct at about 2,000 yards, or that of a projectile fired at 100 yards from a higher level; such, for instance, as that of the "Monarch's" battery as compared with the "Captain's." It was found that at this angle the projectile did not enter the ship, but, after ploughing up the woodwork of the deck, ricochetted off it, and went away screaming and whistling up into the air until lost from sight. One of the disadvantages urged against a low freeboard is thus disposed of as far as 9-in. guns are concerned. The "Monarch," however, is armed with 12-in. guns, and it would be interesting to ascertain whether the above results would hold good in the case of the larger calibre. It seems desirable also to ascertain the actual angle at which a projectile fired horizontally will penetrate a ship's deck protected with as much iron as is admissible in its construction. Ships' decks may often be subjected to a plunging fire from elevated batteries, such as those on Straddan Heights or Gibraltar.

ENGINEERING STRUCTURES.

Elevated Railroad.—The West-side Elevated Railroad, extending from the Battery, at its lower terminus, to 30th street, along the line of Greenwich street and Ninth avenue, has been opened to business long enough to enable the public to arrive at very correct ideas concerning it; and, as far as we have been able to learn from inquiry and observation, the voice of public opinion has long since pronounced it a failure. So far, it has secured considerable patronage during the semi-occasional intervals between break-downs and accidents in which it has been possible to run cars; but there is nothing to indicate that it can ever be made a financial success, since but few of those who pass over it once are well enough satisfied with their experiences as to care to repeat them. Considered simply as an experiment in engineering, there is nothing in the structure or the operation of the propelling machinery to enable an impartial and disinterested critic to pronounce it a success; since it is constructed with but little apparent regard for scientific or mechanical principles; and although it has been found possible to dispatch cars back and forth over the track, the road, as far as completed, does not realize in any sense the expectations of those who have furnished the money expended upon its construction. The method of propelling the cars by means of a succession of endless wire cables is not a success in any respect, as the motion is uneven and disagreeable, and the gradual loss of impetus in passing over the bridges between the sections, necessitates a succession of sudden and unexpected jerks as the tracks attached to the cables come in contact with the spring affixed to the under part of the car. The worst feature of the road, however, is the weakness of the structure, sustained by single posts, and possessing no side braces or supports to overcome the lateral motion of the heavy cars balanced upon the spreading arms that hold the tracks. These defects should have been discovered before 100 ft. of the road had been built, if not sooner, and we are surprised that the plan upon which it is built was not long since abandoned as impracticable. From personal experience, we are forced to the conclusion that it is neither safe, rapid, nor pleasant; and when it shall have ceased to be a novelty, there is but little reason to believe that it will command more than a very limited patronage. But even if it were a success in all respects, it could not carry passengers enough to make the enterprise a profitable one, since the traffic over the single track is necessarily limited. We regret our inability to speak more favorably of the road, but a due regard for candor compels us to say that it does not meet, in any essential particular, the expectations or requirements of the travelling public. It can not be denied that we need better and more rapid facilities of transit within the limits of the city than are afforded by the surface roads and omnibus lines, but something different from the elevated railroad is needed; and, for the sake of those who may be induced to furnish the capital needed to complete the work, we hope the company will not carry out their original intention of extending the road beyond 30th street.—*Iron Age.*

Amsterdam Ship Canal.—Next to the Suez Canal in magnitude is the Amsterdam Ship Canal, which has been in progress about 5 years, and is expected to be completed in 1876. The canal is being formed through two lakes, both of which are shallow, first by making embankments on each side of the line of canal, and then by dredging out the material between to the requisite dimensions. A deep excavation is being rapidly formed from the lakes to the North Sea, through the sand-hills, and outside this piers built of large concrete blocks are in progress, which will extend about a mile into the sea, and enclose within them an area of about 200 acres, which will be dredged to a depth of 24 ft. below low water. The canal will also have 3 locks at the North Sea entrance, a little eastward of the harbor. The canal will have a width at the bottom of 88 ft., which is 16 ft.

wider than the Suez Canal; a width at the top of 195 ft.; and a depth of 23 ft. The locks will be wide enough to admit ships of the largest class.

NEW BOOKS.

Des Machines a Vapeur; Leçons faites en 1869–70 a l'ecole imperiale des ponts et chausées par F. Jacqmin, Ingenieur-en-chef des Ponts et Chaussées, etc., etc. Paris: Garnier Freres. For sale by Van Nostrand.

This work is in two octavo volumes, numbering together 950 pages, and presents a complete discussion of the theory and practice of steam engineering.

Beginning with the theories of heat, the author reviews the labors of Rumford, Joule, Hirn, Mayer and others. Then are presented the laws of vaporization, of specific and latent heat, of the tranformation of heat into force and force into heat, of dilatation of solids, liquids and gases.

In treating of the engine the same completeness is observed. Boilers are first classified, and each class described. Then the conducting pipe, the cylinder, condenser of every kind successfully employed, are each described in proper order, but do not occupy the proportionate space in the book that would be afforded by an English writer.

The metals used in construction of engines receive their full share of attention.

The discussion of the methods of transmission of the force of steam is quite a thorough treatise on mechanism.

The description of all portions of a railway equipment is surprisingly minute.

One defect in the work, which is inexplicable to an English student, is the absence of graphic illustration. Throughout nearly 1,000 pages of description of machines, tools, and mechanical device there is not a single diagram.

Practical Mining Fully and Familiarly Described. By George Rickard. London: Effingham Wilson, 1869. For sale by Van Nostrand.

Within a very narrow compass—for Mr. Rickard's treatise does not exceed the limits of a moderately-sized pamphlet—the author has compressed a great amount of information, which might have been easily distended into a large volume. Indeed, considering the clear and practical manner in which this little book is written, one regrets that the author has not done more. In his opening chapter Mr. Rickard sketches briefly the geology of Cornwall and Devon, for it should be mentioned, that as evidently the author's mining experience has been derived from the practice those two countries afforded, so the contents of "Practical Mining" refer entirely to those ore-bearing districts. But if the various formations are briefly mentioned, their areas, directions, and limits are all carefully described, and the boundaries are identified by the towns and villages which skirt them. This chapter concludes with a notice of special formations, the directions and peculiarities of the metallic lodes, and the phenomena which disturb and break up the veins of ore from their original position.

The grauwake, or clay slate, which surrounds more or less the granite formations, both of Cornwall and Devon, is very productive of minerals, as well as the junction between the two formations; and rings of mines are formed on these lines of junction, some wholly in granite, some wholly in the grauwake, and some in both. The minerals produced from these mines are generally copper and tin. Although the lead mines are sufficiently near the border of the granite to be close to the ring of mines, their continuity is not sufficient to give them the same circuitous route. Lead ore, indeed, is for the most part scattered over Cornwall and Devon, whilst the copper and tin mines are also partially scattered in irregular positions throughout both counties. After some briefly-considered details relating to the preliminary proceedings of speculators breaking new ground, Mr. Rickard proceeds to consider the necessities which ought to rule in fresh work, and to point out the many failures and the great losses which have attended a want of care in the outset; here again the reader regrets that nothing but a recapitulation of the needful considerations is given; and that the author has not dwelt upon them in detail. The same fault, indeed, runs through the whole book, but in every page the author proves his familiarity with the subject. Exception must also be made to the want of method shown in dealing with the theme, which gives an idea of incompleteness, and causes trouble to the reader. These drawbacks, however, manifestly arose either from a want of care on the part of the author, or a lack of experience in arranging his information; faults to be amended without difficulty, and which we hope will be amended in a future and more extended edition.

On the Strength of Beams, Columns, and Arches. By B. Baker, Assoc. Inst. C. E. London: E. and F. N. Spon, 1870. For sale by Van Nostrand.

The subject-matter of this little volume is of great importance to civil engineers. All structures resolve themselves ultimately into beams, columns, and arches, of some kind. It is therefore of great importance that the engineer should be familiar with the mode of ascertaining their strength or their resistance. We approve, in the main, of Mr. Baker's endeavor to dispense with high mathematics by substituting geometrical solutions for ordinary problems, because, unfortunately, mathematics is not the strong side of English engineers, although England has produced the greatest of mathematicians. But the author seems to labor under serious misapprehensions. He proposes his geometrical solutions, because he thinks that the use of mathematics "involves an unjustifiable waste of time, with the great contingent disadvantage that it checks the growth of sound judgment in the engineer, by giving a fictitious appearance of accuracy to his results which are not susceptible of exact deduction." This is a grievous error. The spirit of mathematics is the expression of most acute and refined reasoning; and how can the practice of intellectual reasoning check the growth of sound judgment in the engineer? The fictitious appearance of accuracy above mentioned is altogether beside the question, because it is optional; but not so the correctness of our reasoning and arguments. The author makes the above statement in his preface, and we find, unfortunately, that throughout the volume the spirit of mathematics is sadly offended. Let us take for example the author's mode of calculating the

strength of beams. He shows us how the strength of a beam may be found geometrically, and derives the formulæ for rectangular and other beams, assuming the neutral axis of the beam to pass through the centre of gravity of the sectional area of the beam.

How to Use the Barometer. By the Rev. R. Tyas, M. A., LL.D. London: Bemrose, 1870. For sale by Van Nostrand.

We have often called attention to the great importance of a generally-known and uniform method of making even the simplest meteorological observations; for we are convinced that, till something of this sort is done, the weather statistics collected by the amateur meteorologist cannot be regarded as reliable. Now, the present volume, though it is unpretending enough, and can hardly be styled a scientific treatise, is nevertheless a handy and useful little work, well calculated, we should think, to meet the want we have referred to. It is a short and clear account of the objects of meteorological study, of the form and construction of the principal meteorological instruments, and of the methods of employing these instruments so as to obtain correct records of the condition of the atmosphere, temperature, and so forth. It is published annually, and so, while useful as a handbook to the weather-glass, it is doubly so in a practical sense, by the fact that it contains numbers of blank tables which the young meteorologist can fill up for himself, and thus become thoroughly familiar with the mode of preparing returns. There are a good many illustrations, and one of them—that of the author's thermometer-stand—may offer a hint to many who are ignorant of the fact that records of temperature are useless unless the conditions under which the thermometer should be placed are fully observed. The only part of the book we object to is the introduction, which contains some "fine writing" of a very clumsy character. Practical men should avoid that kind of thing.—*Scientific Opinion.*

The Manual of Colors and Dye Wares. By J. W. Slater. London: Lockwood & Co. Sold by Van Nostrand.

The subject of this alphabetically-arranged manual is to furnish, in brief space, an account of the chemical products and natural wares used in dyeing, printing, and accessory arts—their properties, their applications, the means of ascertaining their respective values, and of detecting the impurities which may be present. Information of this kind seems to be needed both by makers, dealers, and consumers. The author relies more upon strictly chemical methods, as distinguished from rule-of-thumb procedures. He believes there are means of forging those outward features of color, touch, taste, etc., upon which so many rely. It has not been any part of the plan of the book to give receipts either for the manufacture of colors and mordants, or for their applications in dyeing and printing, as there are already books which profess to do so. Few persons, however, are so generous as to reveal to the world the best and newest processes in their possession, as the author remarks, and he himself is no exception to the rule.

In the preface the author alludes to an alleged discovery, which is to rival the tar colors in brilliance and purity.—*The Builder.*

Peat Fuel: How to Make it and How to Use it. By T. H. Leavitt. Boston: Lea & Shephard. Sold by Van Nostrand.

This neat little volume contains practical information of considerable value to those who want cheap fuel in regions where coal is scarce and peat easy to obtain. Hitherto our forests have supplied us so abundantly with wood, in localities remote from coal, that we have never paid much attention to the utilization of a fuel which is doubtless capable of supplying the place of either coal or wood for many purposes. The extensive use of peat in portions of Europe, particularly in parts of Ireland, where "turf" is used almost to the exclusion of every other kind of fuel, is too well known to need further comment. In many instances the peat, merely cut and dried, is used directly as fuel, but there is no doubt that in many cases a more elaborate treatment, as recommended by Mr. Leavitt, will yield favorable economical results. An Irish doctor, writing in 1685, says: "Turf charred, I reckon the sweetest and wholesomest fire that can be; fitter for a chamber and for consumptive people than either wood, stone coal, or charcoal."—*Engineering and Mining Journal.*

The Disposal of Town Sewage. By R. W. P. Birch. A Paper read before the Students of the Institution of Civil Engineers. London: E. & F. N. Spon. For sale by Van Nostrand.

We have before us the reprint of a paper recently addressed to the students of the Institution of Civil Engineers by one of their number; and to the author of which a Miller prize was awarded. The treatise in question is not remarkable as a literary effort, nor for any close investigation of the subject on which it treats, and it is blemished by one or two unfortunate mistakes; but despite these things Mr. Birch's paper is a production worthy of consideration and of study—first, on account of the information it contains and the hints it suggests; and, second, because it may fairly be considered a representative paper of the student class of the Institution.

The author considers his subject under two heads—the disposal of sewage by water carriage, and its direct application for irrigation, and the treatment of it by mechanical or chemical means for the separation of the sewage matter from the water in which it is contained, and the consequent prevention of pollution of rivers into which the water is discharged. Pointing out the drawbacks of the various methods of irrigation by means of porous pipes laid deep within the ground, of hose and jet distribution, and of irrigation by submersion, and the advantages of the remaining plan of surface channels, the author proceeds to illustrate the progress and success of sewage irrigation by the statistics gained by experience in the places where it has been tried. Aldershot, Banbury, Bedford, Croydon, Norwood, Rugby, Warwick, and Worthing are the leading examples of sewage farms, where more or less of success has attended the introduction of this system, so carefully worked out by Mr. Baldwin Latham at Croydon. Turning to the consideration of the mechanical purification of sewage, the author gives an account of the filter beds at Ealing, where 400,000 gals. are passed daily through the settling tanks. There are two of these tanks employed, 64 ft. long by 10 ft. wide by 8 ft. deep each, separated into 4 compartments by timber partitions, which allow

the passage of the water while arresting solid deposit. Flowing to the end of the tank, the sewage first encounters a gravel filter, 12 ft. long and 10 ft. wide. Between these and the filter beds are placed beds of charcoal, retained by iron gratings, through which the sewage passes; flowing up into the first set of filters, formed of burnt clay ballast, thence over a weir into the second filter beds through 2 ft. of ballast. In this way there is a constant flow through 7 ft. 4 in. of purifying material, and the residue mixed with the ashes collected from house to house amounts to 1,000 tons a year, which sells readily.

With regard to the chemical methods of purification, the author describes the first and highly successful lime process of Higgs and Wickstead, dating so far back as 1846 and 1851, and arrives at the conclusion, borne out by experience, that this plan, if properly carried out, although costly, is yet an effectual means of purification.

Of all the chemical and other systems, however, recommended by the author, the one known as the A B C process is most favorably thought of by the author, and it is this portion of his paper we had in mind when we complained of its shortcomings. For while it is evident that the essay on "The Sewage Question" leads up to Messrs. Sillar & Wigner's process, which is dwelt upon at considerable length, and while the author is "confident that their plan is a profitable and inoffensive one for extracting valuable manure from sewage," we find in a foot note that "circumstances have come to light in connection with the carrying out of the A B C process at Leamington, that have caused the author to entirely change his opinion as to its efficiency, both in a sanitary and commercial point of view." Although this latter conviction is confirmed by the Rivers Pollution Commissioners, who have recently condemned the A B C process "as expensive in its appplication and unsatisfactory in its results," it is nevertheless unfortunate that the opinion so confidently expressed in May, should be contradicted two months after, and that only by mere assertion. Such a fault as this, however, in a really useful essay, is very pardonable, and is an illustration of what we just now mentioned as a fault of the student's papers, where conclusions arrived at in a hurry, and placed on record, have sometimes to be retracted afterwards.—*Engineering*

On the Application of Cast and Wrought Iron to Building Purposes. By Sir William Fairbairn, Bart., C. E., F. R. S., etc. 4th edition, with additions. London: Longmans, Green & Co. 1870. For sale by Van Nostrand.

In this new edition of a standard work there is a considerable amount of new matter, including a careful revision of the third edition, and an enlargement of the work. It now contains an experimental inquiry into the durability of wrought-iron beams and girders, the influence of the force of impact, and a long series of changes of variable loads affecting their ultimate powers of resistance. These researches are of high importance, when considered as a safeguard to the amount of load or strain to which beams or girders are usually subjected. In this edition there will also be found experimental researches on the properties of steel and homogeneous iron, to which the architect and engineer may safely refer; and as these investigations have reference to a material which may ultimately take the place of iron where security and strength are required, the author states that he has no hesitation in submitting it to the consideration of his readers. In an appendix is given a series of experiments on timber trussed beams, showing the comparative value between wood and iron in that form. It shows the principle on which wood and iron trussed beams should be constructed.

Protoplasm, or Life, Matter and Mind. By Lionel S. Beale, M. B., F. R. S. London: J. Churchill & Sons. For sale by Van Nostrand.

This is by far the most thorough and scientific examination of the "physical basis" question we have yet seen. The spirit and intention of the author are fully shown in the following extract from the preface:

"My views upon the nature of vital actions are at variance with the doctrines now generally entertained and taught. I am therefore very desirous that those interested in the subject should have in small compass the general statement of the facts as they appear to me. It is to be regretted that upon the most elementary propositions connected with this inquiry, opinions are sadly conflicting, and many of the facts and statements upon which they are based and which are urged in their behalf are quite irreconcilable with one another. It is therefore very difficult for readers to form an impartial judgment. But I trust it is not too much to ask that the observations which have led me to the views I entertain, should be brought under the notice of those who have not yet subscribed to the doctrine that living things are mere machines built up by physical forces only, and made to act by force alone.

"Intense energy and activity are displayed by certain members of the new school in giving publicity to their views; they press them in many different forms, and endeavor to enforce the acceptance of the physical doctrine of life, and much besides which it is supposed to include, with all the proverbial ardor and authority of prophets. All this renders it very desirable that every one who is engaged in actually investigating a matter of such deep general interest should do his utmost to make the conclusions at which he arrives intelligible, without affectation of learning, without mystery, and without in any way exaggerating the importance of what he may have to communicate. For the public may reasonably desire some calm statement of proved facts in a matter of such importance. It should be the writer's endeavor to tell his story simply, so that those who wish may learn, and to take pains to make the facts as clear to other minds as they appear to his own, without trying to amaze by calling in the aid of startling similes and striking illustrations, which but too often divert the attention from the real matter under consideration, and are calculated to distract the mind and prejudice the judgment."

Spectrum Analysis: Six Lectures Delivered in 1868, before the Society of Apothecaries of London. By Henry E. Roscoe, B. A., Ph. D., F. R. S. Second edition. London: McMillan & Co. For sale by Van Nostrand.

This new edition of the elegant volume of last year contains many important additions. The ac-

tive workers in this department of science have done much in the last twelve months to extend our knowledge, especially of the physics of the sun. The whole of that portion of the book relating to celestial chemistry has been rewritten. Late papers to learned societies appear as new appendices, and the work is further enriched by several new illustrations.

NOTES OF A COURSE OF NINE LECTURES ON LIGHT, DELIVERED AT THE ROYAL INSTITUTION OF GREAT BRITAIN. By JOHN TYNDALL, LL. D., F. R. S. London: Longmans, Green & Co. For sale by Van Nostrand.

These are brief notes of the author's lectures, but contain a complete exposition of the science of Optics. They will prove invaluable to the teacher who desires the most concise statement of our present knowledge of this science, and notwithstanding the brevity of treatment the general scientific reader may find here a satisfactory elucidation of those rarer phenomena of diffraction and polarization which the more ponderous works frequently omit to discuss, or quite as often obscure by their use of intricate formulas.

MISCELLANEOUS.

A PNEUMATIC TELEGRAPH.—An Italian gentleman, Signor Guattari, exhibited at work, at 66 Gloucester-street, Warwick-square, Pimlico, a system of telegraphing, whereby he worked a Morse instrument at the end of a long pipe by means of compressed air. The pipe, which was coiled round a drum, was of vulcanized india-rubber ; it was about $\frac{1}{2}$ in. in internal diameter, and was stated to be about 500 metres in length. The rest of the apparatus consisted of a copper chamber containing compressed air, an air pump for charging the chamber, and a "key" or commutator, to let puffs of air traverse the pipe to work the Morse instrument at the end thereof. With these appliances the inventor sent messages, which were very clearly printed, by the Morse, when the rate of serving was about half that of the ordinary rate of electrical signalling. With the exception of the air-pump, the first cost of the apparatus is slight, since messages may be sent by abolishing the "key" altogether, and timing the impulses by simply pinching the india-rubber pipe with the figures. For short distances, where a speaking tube can be used, the speaking tube is the cheapest and most expeditious instrument, and against it Signor Guattari's apparatus stands no chance. The greater the distance the more will the elasticity of the air, and its friction against the sides of the pipe, make the air impulses run into each other, and diminish the speed of signalling, and no very long line can possibly be worked by the system to commercial advantage. It may, however, do for distances rather too great for a speaking tube to be applicable. In such cases, its advantage or disadvantage, as compared with a Morse telegraph worked by electricity, is a question of cost of air-pump and tubes, as compared with cost of batteries and wires. The inventor told us that the pressure he used while signalling before us was only $1\frac{1}{4}$ atmospheres ; if, by the aid of a head of water, or in any other way he can get the pressure, thereby abolishing the rotary air-pump and diminishing the expense, his plan would be able to compete better with other systems. He has succeeded in making his apparatus work well, and the question of its adoption to signal messages to stations a little further than can be reached by speaking tubes, is simply one of cost. The inventor says that "he has already been rewarded with the gold medal of the Italian Royal Society of Arts ; obtained the support and recommendation of Prince Humbert ; and the Italian Government has adopted the system, and given orders for its use on board all the men-of-war comprising the Italian navy."—*Engineer.*

THE BRITISH AUSTRALIAN TELEGRAPH.—The British Australian Telegraph Company state that they have received information to the effect that the South Australian Government will give every facility for the landing of their cable at Port Darwin, and that the Government undertake to introduce a measure immediately after the new Parliament meets, for providing by means of a loan for the construction at once of a line of telegraph from Port Augusta to Port Darwin. To remove all cause of jealousy, as well as to provide an alternative line, Queensland would be invited to connect at some convenient point. The company would then have a connection with two independent routes, which would make them secure from interruption. The South Australian Government will not only undertake the construction, but the maintenance of the land line.

A PARLIAMENTARY paper of London gives copies of report and correspondence as to the reward to inventors proposed in the army estimates for the current financial year. These rewards are as follows: A grant of £100 to Mr. C. F. Guthrie, for an ingenious and efficient rolling bridge, applicable to defensive works. It is proposed to pay the sum of £500 to Mr. S. A. Goddard, for his improvements in breech-loading cannon. In the case of Mr. Parsons, who alleged that the Palliser gun was really invented by him, the matter has been referred to Mr. Gregory, the President of the Institute of Civil Engineers. The Treasury has sanctioned a grant of £500 to Commander Colomb, as a final reward, on account of his signals for naval and military use. The Treasury has also resolved to ask Parliament for £1,700 to be granted to the representatives of the late Jacob Snider, for his invention of breech-loading rifles.

AN improvement has been made in the manufacture of carbonate of lead, by the action of the soluble acid carbonates of the alkali on litharge, hydrated oxides of lead, or insoluble basic salts of lead, with an equivalent of bicarbonate of soda, together with sufficient water to form a stiffish paste. This mixture is ground in a suitable mill, small quantities of water being from time to time added as may be found requisite, until the change of the lead bodies into carbonates is complete. The paste is now well washed with water, and the supernatant liquid which contains the carbonate of soda is separated from the white lead by filtration, and boiled down to dryness, and disposed of as soda-ash ; or it may be crystallized, or may be again converted into bicarbonate of soda by treatment with carbonic acid, and used to convert further quantities of lead oxides or insoluble basic salts of lead into carbonates.

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ROYAL AGRICULTURAL SOCIETY'S ENGINE TRIALS.

From "Engineering."

It is not a little curious that the only systematic trials of steam-engines conducted in this country should be carried out under the auspices of a society representing a branch of our industry, which has perhaps more recently than any other of even approximate importance availed itself of the aid of steam power. The reason, however, of this fact is sufficiently obvious. At the time that the Royal Agricultural Society of England was called into existence, agricultural implements were very crude affairs compared with those in use nowadays, and the makers of these implements were, as a rule, men who had little knowledge of true principles of construction. One of the duties of the Royal Agricultural Society was to improve this state of matters by the periodical examination of the various classes of agricultural machinery, and by the award of premiums for the best examples in each class; and when steam-engines—first fixed and subsequently portable—began to be employed by farmers, the Society naturally included them amongst the appliances to be subjected to competitive examination.

That these examinations, coupled with the extra competition between makers which inevitably springs from them, have on the whole been attended with highly satisfactory results, no one who is acquainted with the subject can fairly doubt; but we nevertheless consider that the time has arrived when a modification of the conditions under which the trials are carried out is greatly to be desired. The chief object of the competitive trials is, as we understand it, to do for the farmer that which he has no opportunity—even if he had the skill—to do accurately for himself, namely, to determine which is the best engine out of the variety submitted for examination. And by "best" engine we here mean that which is the best adapted for the farmer's use; not necessarily that which runs the greatest "mechanical time" with a given quantity of fuel, but that which under the conditions under which it will have to be employed will give its purchaser the best return on the money invested in it. A secondary object of the trials—and a very justifiable object too—is to reward those makers by whom the best engine is manufactured. Now, we do not hesitate to say that the regulations under which the Royal Agricultural Society engine trials are at present carried out are not such as to secure the attainment of the objects we have mentioned; and although we believe that in the majority of cases the prizes have been awarded to those makers justly entitled to them, yet this has been due, not to the efficiency of the rules, but simply to the fact that makers who have turned out best "racing" engines have real-

ly ranked amongst the best makers of ordinary engines also. This, however, is not as it should be, and we therefore deem it advisable that in future trials other and more perfect regulations should be adopted. Before pointing out, however, the alterations which we consider to be desirable, it may be as well—for the benefit of those of our readers who are not conversant with them—that we should state briefly the principal features of the existing rules.

The engines which have so far been subjected by the Royal Agricultural Society to trials on the friction brake, may be divided into four classes, namely: 1st, fixed engines without boilers; 2nd, ordinary portable engines with single cylinders; 3rd, portable engines with double cylinders; and 4th, semi-fixed engines with boilers combined. These several classes we shall consider in the order in which we have mentioned them. First, then, with regard to the fixed engines without boilers. According to the Society's rules as adopted for the Oxford competition, these engines are not to exceed 10-horse power nominal, are not to have cylinders exceeding $11\frac{1}{2}$ in. in diameter, and are to be worked with steam at 50 lbs. pressure, supplied from the Society's boiler, which is to be stoked by a man provided by the exhibitor whose engine is under trial. The load on the friction brake, also, is such that the engine, when running at its nominal speed, will just give out its nominal power, and the trial consists in ascertaining how long the engine can be kept running under these conditions on an allowance of 14 lbs. of coal per horse power. Now, the least consideration is required to show that these regulations are little better than absurd. In the first place, the employment of the erm "nominal power" is itself an absurdity; but inasmuch as it is still employed commercially, we may allow it to pass, notwithstanding its indefiniteness. Next, we have the limitation of the size of the cylinder, which is perfectly useless, as, so long as the power to be given off at the brake is not to exceed 10-horse power at the nominal speed of the engine, no maker at all acquainted with the action of a steam-engine would dream of employing a larger cylinder than he is compelled to do, in order to give his engine the appearance of being, commercially, a "ten-horse" engine. Next, we have to find fault with the steam pressure, which is too low, and the load, which is too light. At the time when the Society's engine trials were commenced, 50 lbs. per square in. was no doubt deemed a high pressure; but nowadays it is universally acknowledged to be considerably below that at which non-condensing engines can be economically worked, and in future trials the pressure should be raised certainly to 80 lbs., or still better, to 100 lbs. per square inch.

Then, again, the cases are extremely rare in which an engine rated commercially as a "ten horse" is worked at but ten-horse power. As a rule such an engine has to develop quite 15 or perhaps 20 actual horse power, and it is therefore an absurdity to test an engine with a load so greatly below that which it will have to develop in actual practice. Moreover, the practice of running the competing engines with such a light brake load is a direct inducement to the production of a class of engines possessing many peculiarities which are not merely not beneficial, but which are really objectionable in an engine intended for ordinary work. Thus a maker who desires to obtain a really successful result under the Royal Agricultural Society's conditions, must either construct an engine with a much smaller cylinder than is ordinarily provided with an engine rated commercially at the same nominal power, or he must employ the ordinary proportions and run the engine with a very low piston speed. If he does neither of these things he will have either to wiredraw the steam, or cut it off at such a point that it will expand below the pressure of the atmosphere before the end of the stroke is reached, both these being wasteful alternatives. But if the size of the cylinder is reduced below that usually employed in an engine rated commercially at the same power, there is an opportunity afforded for reducing the dimensions of other parts also, and the maker has every inducement to avail himself of this opportunity, and of the reduction in the friction which it enables him to effect, the result being a "racing" engine of inferior value to a purchaser. We know that there are makers, and very successful makers too, who although they reduce the size of the cylinder of their racing engines, yet provide

working parts with ample bearing surfaces, etc., for a much heavier load than those against which the engines are worked ; but the fact that these makers are conscientious enough to do this does not alter the fact that the conditions of the trials are such as to directly encourage an opposite practice.

Another point open to strong objection is the mode in which the performance of the engine is estimated. At present this duty is represented by the time which the engine will run with a certain allowance of coal, or, in other words, by the amount of coal used per horse power per hour. The duty thus estimated, however, is evidently dependent on three things besides the good or bad qualities of the engine, these being the quality of the fuel used, the evaporative power of the boiler, and the skill of the stoker. Inasmuch as the same boiler and the same quality of fuel are used throughout the trials, these two elements may not greatly affect the comparative results so long as the conditions of weather remain the same ; but with the skill of the stoker the matter is different. No one can admire thoroughly good stoking more than we do, but we, at the same time, have a strong objection to the testing of an engine being conducted in a manner which renders the result in a great measure dependent upon the skill of the man in whose charge the boiler is placed. The proper plan would be to allow each engine a given weight of water evaporated under a given pressure, or, in other words, a given weight of steam, and to estimate the performance of the engine by the weight of steam used per horse power per hour, instead of by the weight of fuel burnt. This plan would further have the advantage of rendering the results obtained on the trial field comparable with results obtained elsewhere, without introducing complications due to the evaporative powers of different boilers, and the relative skill with which they are managed.

Briefly stated, we consider that the conditions for testing the fixed engines at the Royal Agricultural Society's meetings should be somewhat as follows : First, that the term "nominal horse power" should be abolished, and that the competing engines should be merely required to develop a certain actual horse power—say 15-horse power on the brake ; secondly, that the pressureof steam used should be raised to 80 lbs., or 100 lbs. per square in. ; third, that no limitation should be placed upon the size of the cylinders, but that the makers should be at liberty to compete indifferently with small engines running fast or larger engines running more slowly, the sole condition in this respect being that they should do the full work during trial; fourth, that no engine should be allowed to run with a less clearance between the piston and the cylinder covers than would be allowable in regular work, and that the least clearance allowable in engines of different sizes should be clearly stated in the conditions of trial ; fifth, that special attention should be paid by the judges to the proportions of the working parts, the area of the wearing surfaces, and the provisions for lubrication ; sixth, that each engine should have all bearings, etc., well oiled before starting on its trial, and that it should receive no further lubrication until it had run at least two hours ; seventh, that the duty of the engine should be estimated from the weight of steam and not from the weight of fuel used ; and eighth, that no special appliances or "dodges" should be allowed to be employed during the run which could not be used in ordinary practice.

In the case of the portable engines tested by the Society, the practice at present is to limit the boiler pressure in the case of single cylinder engines to 50 lbs., and in the case of the double cylinder to 80 lbs. per square in., and to give to each engine brake load corresponding to 1-horse power for each 10 circular inches of piston area in the former case, and each 9 circular inches in the latter. The allowance of coal is 14 lbs. for each horse-power thus estimated, and the general conditions of the run are similar to those we have mentioned when speaking of the fixed engines, save that in the case of the portables, each engine is, of course, supplied with steam from its own boiler. In this case, where the engine and boiler have to be tested as a whole, it is undoubtedly difficult to get rid of that variable element, skill on the part of the stoker in charge, and in fact, the only way in which it can be overcome, so far as we can see, is to encourage each competitor to employ the very best man obtainable by making no allowance whatever for bad firing.

In the case of portables it would, we think, be advisable to abolish the existing

differences between the single and double cylinder engines, and to divide all the engines into three classes, according to the pressure of steam at which their boilers could be worked with safety. The limits of pressure for the three classes might be taken at 60 lbs., 90 lbs., and 120 lbs. per square inch respectively, this latter pressure being one at which steam cultivating engines are now often worked. As in the case of the fixed engines, we should propose that the classification by "nominal" power should be abolished, and that a certain scale of brake loads—say 10-horse, 15-horse, and 20-horse—should be determined upon, for either of which a competitor should be allowed to enter his engine irrespective of the size of cylinder of the latter, the only condition being, as in the case of the fixed engines, that the work should be done fairly, and that each engine should be tried on two different loads.

As in the portable engines it is the combined performance of the boiler and engine which has to be tested, it would be necessary to estimate the duty of the engine by the consumption of fuel as at present; but at the same time we think that the evaporative power of each boiler should be accurately ascertained and noted in the report on the trials. As regards clearance in cylinders and similar matters, the conditions we have given for the fixed engines might, we think, be adopted, and means should be taken to guard against the employment of unusually thin tubes, or fire-box plates, loose contracting ferrules, and other racing dodges which could not be advantageously employed in regular work. The present regulations requiring the tubes to be at least $2\frac{3}{4}$ in. in diameter and 1 in. apart, might, however, we think, be somewhat modified with advantage.

Of the semi-fixed engines it is unnecessary that we should speak at any length, as the regulations for their trial might, we think, be in the main identical with those adopted for the portable engines, some attention, however, being also paid to the floor area and cubic capacity of the space respectively occupied by the competing engines.

We have very far from exhausted the subject of agricultural engine testing; but we have endeavored to point out what we consider would be some desirable alterations in the Royal Agricultural Society's rules. Our object in proposing these modifications is to insure that the winning engine in such competition shall be more nearly a true representative of an engine that would give really good results in regular work than is likely to be the case under the present circumstances; and at the same time we desire to open the way for the employment of higher piston speeds and greater measures of expansion than the present conditions allow. In addition to noting the points we have mentioned, we consider, also, that the judges should have indicator diagrams taken from the engine whilst under trial, and the observations recorded should in fact be so complete that there should be no difficulty in discovering the true reason of the good or bad performances of any engine submitted for competition. At some future time we may have something further to say on this subject, but for the present we must conclude with a few remarks on some minor alterations in the mode of carrying out the tests, which we think would facilitate operations. As matters at presend stand, the three brakes used by the Society have belt pulleys of slightly different sizes, and as no limitation is placed upon the size of the flywheels of the engines or on the speed at which they are driven, each brake load and the corresponding speed of the brake has to be calculated separately. These calculations are of course of a very simple character, but at the same time they involve no small amount of trouble and occupy time which can ill be spared. To avoid this trouble we should propose, 1st, that the radius at which the weight is hung on the brake should be such that the circumference of the corresponding circle should be 17.5 ft.; 2nd, that the weight of the scale pan on the brake strap should be counterbalanced; 3rd, that the brake speed should be fixed in all cases at 100 revolutions per minute; 4th, that all the brakes should have belt pulleys of equal diameter, say 50 in.; 5th, that each engine sent for trial should have a flywheel or belt pulley of a diameter (supposing the dimensions just mentioned to be adoped for the belt pulley on the brake) in inches equal to 5,000 divided by the nominal speed of the engine in revolutions per minute. Supposing these conditions to be adopted each 2 lbs. load placed on the

scale pan would represent a load corresponding to 1-horse power, and each 100 revolutions of the brake would represent one minute of "mechanical time," so that the latter would be obtained by simply pointing off the two right hand figures from the number indicated by the brake and counter.

LECTURE ON TELEGRAPHY.

From "The Electric Telegraph and Railway Review"

The Rev. Arthur Rigg, M.A., delivered an entertaining and lucid lecture, at the Horological Institute, on "The mode of discovering the distance from the shore of a break in a Deep-Sea Telegraph Cable."

The lecturer commenced by explaining the great importance of being able to determine the whereabouts when a breakage occurs in a submarine telegraph cable, so that a vessel may be at once sent to the spot to pick up the cable, and effect the repairs. Otherwise it would be necessary to pick up a loop of the cable, and, passing it over a wheel inboard, underrun it to the great risk of again breaking it, to the broken places at an unknown distance. In thc case of the Atlantic Cable it might be any distance from 1 mile to 3,000 miles.

The lecturer then stated that different metals possess different degrees of conductivity for electricity, and that as the conducting power became less the resistance to the passage of electricity from end to end of the metal was greater.

The following table will show the comparative conducticity possessed by seven different metals, beginning with silver as the best :—

Silver	100
Copper	77.4
Gold, fine	55.2
Iron	14.4
Platinum	10.5
German Silver	7.7
Mercury	1.6

Wires of these metals required to conduct a given amount of electricity in the same time to the same distance would require the squares of their diameters, or the areas of their sections, to be in an inverse proportion to their conductivity. For instance, a German silver wire, to conduct the same amount of electricity with the same resistance as one of pure silver, must contain 13 times as much metal in the same length, or in other words must form a wire containing the bulk of 13 wires of pure silver.

For the same material, the amount of resistance offered to the passage of the electric current is in an inverse ratio to the size of the wire. Thus, if a pound of wire be only one yard in length, the resistance offered to the current will be 1,760 times less than the resistance offered by the same weight of wire drawn to the length of a mile.

Having thus prepared his audience by preliminary information of this nature, the lecturer proceeded to explain the construction of the instruments used in the course of the lecture ; first, the resistance coils, which instrument is constructed to show the resistance up to 999 ohmads or British Association units of electrical resistance, asking the audience should he call them by that name or call them pounds ? It was decided to call them pounds ; so that when comparative numbers as to resistance occur, they will be termed pounds. This instrument is composed of a quantity of German silver wire of different sizes, coiled on bobbins, so placed that a current of electricity can be sent through one or more at the same time. This is effected by an arrangement which was shown on the top of the box containing the coils of wire, and was described by the lecturer as a group of islets surrounding a large island, and separated from it and from each other, but could be connected by means of a brass plug, or bridge, and in accordance with the position of this plug was the amount of resistance increased or lessened in decimal ratio, as units, tens, hundreds, etc.

The next portion of the apparatus was the Wheatstone-bridge, invented by Sir C. Wheatstone, by means of which a current of electricity may be split, one portion of the current (or, as in the language of the leturer, electrical passengers,) going in one direction, through the cable to be tested, the other passing through the resistance coils as the means of ascertaining the amount of resistance, both portions finding their way back to the battery. This was very clearly illustrated by

some well-executed diagrams showing the whole of the two routes of the electrical passengers from the battery, the one route through the cable and earth, the other route through the resistance instruments,—both routes ending in the battery. The reflecting galvanometer invented by Sir William Thomson was next described. Its construction is exceedingly simple, being merely a small astatic combination of two magnetic needles suspended by a single fibre of natural silk. Attached to the needles is a small mirror. One needle is surrounded by a coil of copper wire covered with silk. A lamp was so placed as to throw a streak of light through a slit on to the mirror, whence it was reflected to a long strip of paper divided equally like a rule. By this arrangement the slighest motion of the mirror was increased in direct proportion to its radial distance from the scale. This instrument is so exceedingly sensitive that the lecturer said, it was possible to waft a kiss across the Atlantic Ocean; in illustration he showed a sensible deflection of the needle by merely placing on the tongue a threepenny piece and a small piece of zinc, and sending a galvanic current through the 999 units of resistance to the galvanometer. The reporter has himself seen the same effect produced by the same means through the whole length of the Atlantic cable on board the Great Eastern.

With these instruments and a small battery composed of zinc and copper, in a vessel no larger than a wine glass containing a solution of common salt, the lecturer proceeded to demonstrate the practicability of discovering the locality of a break in a submarine cable. Having attached his battery and connected the several wires to their proper terminals, the lecturer showed the use of the resistance coils by moving the plugs into various positions. The result was shown by the motion of the streak of light on the divided scale. The course of the electric current and the use of the earth plates were then explained by means of diagrams showing that a plate of copper buried in the earth and connected by a wire to one pole of a galvanic battery, the opposite pole being connected with one end of a submarine cable, crossing the Atlantic or other ocean, and then connected with a similar plate of copper buried also in the earth, the electric circle is completed through the earth at whatever distance it may be. By inserting the necessary indicators and other apparatus, at the various stations, messages can be transmitted.

If the cable should be broken or so injured that the conducting wire is exposed to the water, that is termed "making earth," and the signals, instead of passing to the other side, return through the earth to the home plate, thence to the battery from whence they started. Prior to the discovery of the earth circuit by Steinheil about the year 1847, whenever a telegraph line was constructed, two wires were placed the whole distance in order to complete the circuit, thus doubling the cost.

The lecturer next proceeded to show the method of discovering the distance of the fracture from the shore; and, as he could not demonstrate it by means of an actual cable, some bobbins of fine wire were made to represent one, in addition to which about 300 yards of fine iron wire were wound about the room. By attaching the two ends of that wire in two binding screws of the Wheatstone-bridge and connecting the little wine glass battery of salt and water also to the bridge, the whole of the current would pass through the wire or cable to the battery. By connecting the resistance coils to the other side of the Wheatstone-bridge the two routes were completed and the electrical passengers were started on their journey, the object being to discover what amount of resistance they would meet with and where, opposing their return to the spot whence they started and to which they were seeking the easiest route, for back they must come.

The circuit being complete, if the resistance offered by the cable (as the lecturer called the fine iron wire before mentioned) be greater than that offered by the resistance coils, the streak of light will move in one direction, and if less it would be deflected in the opposite direction, and by shifting the brass plugs, connecting the islets with the island, till the reresistance each way is equal, the streak of light rests at zero, in the centre of the scale. In this instance the resistance was 70 units, and as that is equal to about $4\frac{3}{4}$ miles of copper wire of No. 16 gauge the length of the wire would have been $4\frac{3}{4}$ miles, or the broken place would be $4\frac{3}{4}$ miles from the shore. To carry it still further, if we assume the 70 units to mean 70 miles, then

the break would be found 70 miles from the shore. This may perhaps be made plainer to non-professional readers in this way :— There are 100 electrical passengers to start on a journey and an arrangement is made by which two ways are open, and they start 50 each way; arriving at a certain point on one route, there is a resistance to their passing and only 25 can get through, the remainder turn back and take to the other or easier route. To enter upon this route they must pass through the wire of the galvanometer. In doing so the little speck of light is caused to move; and thus, as by a pointer on the scale-beam, is indicated the direction in which these electrical passengers are travelling, and therefore on which side the greatest resistance to their passage is found. The same experiment was shown through two bobbins of fine wire, in which the resistance was equal to 500 units, equal to 33½ miles of No. 16 copper wire; so that in a cable composed of such wire the injury would be 33½ miles from the shore.

A very novel and simple battery was then shown, being two small ribbons of metal, each ¼ in. wide and 3 in. long, one zinc and the other copper, stuck into a potato. Attaching the wires to the resistance coils and the galvanometer, very sensible deflections of the needle were produced through the whole 999 units of electrical resistance. It is obvious by comparison that the same effect would have been produced through a telegraph line composed of 66 miles of copper wire of No. 16 gauge. In conclusion, the lecturer stated that he believed many of the phenomena of electricity were still hidden, and it may fall to the lot of some now living to see this agent used as a motive power in the place of steam, and as heat in the place of fuel, and as light in the place of gas.

BRONZE GUNS.

From "The Engineer."

The recent introduction of a bronze muzzle-loading field gun for the Indian artillery by General Wilmot's committee, and the possible adoption of the same class of weapon for the English artillery generally, has given an importance to the experiments now in progress in Belgium with bronze guns, which a few years ago they would hardly have possessed. It is a significant fact that there are assembled at Liége at this moment artillery officers from nearly every European nation—including our own—for the purpose of watching experiments with bronze guns. A few years ago this would have been impossible. The nations seemed to be gradually settling down with their steel or wrought-iron field guns, or with systems less costly and less efficient; and among things of the past might, except in a few rare instances—as in France—be ranked bronze field guns. Those which existed were for the most part in process of supersession. But the tide has lately turned—for our country, at least, it has done so—and elsewhere experiments have been for some time in progress, the object of which is the application of bronze to rifled guns. Every one knows the merits and defects of that material for cannon. Its conspicuous merit is its toughness and resistance to explosive bursting. Whatever a bronze gun may do, and however it will fail, it will assuredly not burst explosively like steel or cast-iron. The metal has other advantages, not the least among which is its adaptability for conversion. When your bronze gun is worn out, or when the pattern is superseded, you have always so much valuable metal which can be sold or recast. And the lightness of the metal is a further recommendation in the eyes of the artillerist. But for rifled guns bronze has always been supposed to possess certain important disadvantages—chief among which is its softness and liability to injury by the friction of the studs, or the mechanical action of the powder gas. Until General Wilmot's committee proved that it was otherwise, experienced men declared that no bronze gun could long stand the destructive action of a rifled projectile. It was known that the French guns wore out with a rapidity which might be inconvenient on a campaign. But the committee which we have named proved that by adopting a narrower groove, and by care-

fully adjusting the height of the studs in relation to the groove, a bronze gun might be made to endure a vast amount of firing without becoming unserviceable. Two guns have, at the hands of the committee, endured respectively 2,673 and 1,362 rounds with charges relatively higher than those of any other rifled gun in Europe, and still remain perfectly serviceable. These figures, translated into plain English, mean a life of 53 and 27 years' ordinary service. It is clear, therefore, that bronze may be perfectly serviceable for rifled field guns. On the other hand, it was urged that these results could only be obtained by adopting very soft metal for the studs. But, as General Wilmot's committee observes, "when put to the test of experiment this objection is found to be completely without foundation. The zinc studs are but little liable to injury by the rough treatment. Nothing short of intentional injury can render the projectiles thus studded unserviceable." As to the scoring of the grooves, from which much was feared, the practice is not thereby materially affected, the scoring being confined to the loading side and bottom of the bore. Further, when shells were burst by the committee within the gun, the serviceability of the weapon was not interfered with. But, for all that, it is evident that if bronze can be made at once harder, more resisting, and more elastic, it will be, *pro tanto*, a superior metal for artillery purposes. There is more than one direction in which it may be possible to work with advantage. There is first the direction of chill-casting; secondly, that of casting under pressure; thirdly, that of hardening the alloy. It is with the first and third of these expedients that the Belgian experiments connect themselves. Messrs. Montefiori-Levi and Kimtzell, nickel manufacturers, of Val-Benoit, near Liége, have for several years been experimenting with bronze. They have lately conducted a series of systematic experiments with bronze hardened in various ways. They found that by casting ordinary bronze in chills its hardness and tensile strength were greatly increased. By alloying a small proportion of phosphorus with it they found that an immense augmentation of strength and hardness was the result. After satisfying themselves by various tests—conducted chiefly by Mr. Kirkaldy—that phosphoric bronze cast in chill is, as far as the resistance to statical pressure and strain is concerned, vastly superior to ordinary bronze, however cast, they deemed it worth while to institute, under the auspices of the Belgian Government, a series of gunnery experiments with the new metal. Perhaps "new metal" is hardly the correct expression to use, and its employment without qualification may provoke discussion. Phosphoric bronze has long been known, and, to a certain extent, employed in this country. In 1861 experiments were made with it in the Royal Gun Factories at Woolwich. Dr. Percy, in his work on "Metallurgy," treats of it. Professor Abel has written one or more treatises on the subject. Mr. Forbes, of Birmingham, has employed it, and perhaps does so still—we believe that he even took out a patent for the metal—and elsewhere phosphoric bronze has been experimentally employed. But until the present time no formal and systematic experiments have been made, or perhaps, we should say, no experiments so formal and systematic as those conducted by Messrs. Montefiori-Levi and Kimtzel, and now in their final stage of progress in Belgium, have ever been carried out. To detail the results of the statical and other experiments on the new bronze would occupy more space than we can afford to the subject. It will be sufficient to state briefly what is now being done. Two guns have been cast—small smooth-bore muzzle-loaders—one of the ordinary and one of the phosphoric bronze, the latter having been cast in chill. These guns are being tested for hardness, for resistance, for non-liability to corrosion. The experiments—which are being carried out at Liége by the Belgian officials, in the presence, as we have stated, of representatives from nearly all the European nations—will probably continue throughout the present month. Thus far, we are informed, the new metal has established a great superiority. But the tests thus far applied have only gone so far as to measure the relative hardness of the two cannons. That the new bronze is far harder than the other is fully proved. It remains to be seen if it is equally resisting to the explosive and mechanically destructive effects of gunpowder. To prove this the tests will be pushed *á l'outrance;* and further, a breech-loading

rifled gun of phosphoric bronze will be tried, to determine the suitability of the metal for pieces of this description. The direction in which the new metal appears most likely to fail, if at all, is in its susceptibility to be burnt or eaten into by the powder. This is inferred from the fact that a breech-loading small-arm, of which the breech was made of phosphoric bronze, showed signs of deterioration after a few cartridges, made purposely defective, had been fired in it. The gun now under trial, we are informed, has not exhibited any symptoms of failure of this sort. It is, therefore, too early to express any decided opinion upon the subject. We hope, as the experiments progress, to be able to keep our readers informed as to the results, which are exciting a good deal of interest. It should be mentioned that an important advantage obtained by the use of the new bronze is the remarkable homogeneity and conformity of the casting, and the absence of any necessity for casting with a " dead head." Those who are familiar with the operations of bronze casting will be able to appreciate these advantages, quite independently of any merits which the new metal may possess for artillery purposes. The phosphoric bronze gun now being tried at Liége was cast without any dead head at all; it was cast also by inexperienced men, with rude appliances, in a nickel factory, and yet it has already worn out one gun of ordinary bronze which was opposed to it, and is still, we are informed, quite serviceable.

SWEDISH RAILWAYS.

From " Engineering."

This commnication suggests some considerations of great practical interest not only to Sweden, but also to our own country. From the information thus furnished we may conclude that in Sweden, as indeed in many other countries, the mistake has been committed of adhering to one particular system of railways, copied from England or from some part of the Continent, without paying due regard to the differences in the physical and social condition of the two countries, such as the sparseness of population, the small amount of traffic, and the limited means at the disposal of the nation for further construction; and although we have no fault to find with the construction as far as it has hitherto been carried out, it must be admitted that the delay in completing the entire system of railways must have greatly hindered the development of the resources of the country. But as industrial speculation has increased, the railway fever has now again become rife in Sweden, and there is naturally a voice of warning raised against the extravagance of continuing the old expensive system of railways. This has consequently led to a contest between politicians and engineers, the men who grant the money and those who spend it. The contest has, however, been nobly conducted, and free from personalities, while both sides of the question have been fairly enough argued. In pronouncing a decision in the case we think that it requires but little consideration to declare in favor of the Government, who propose to complete the system with the 4 ft. $8\frac{1}{2}$ in. gauge, but with light rolling stock, using, however, for branch lines the 3 ft. 6 in. gauge.

Similar questions are now in agitation with respect to the extension of railways in Russia, India, and Canada. Two 3 ft. 6 in. lines are being experimentally constructed in Russia, the one by the Government, and the other by private capitalists. Should this experiment be successful it will decide the adoption of that gauge for the extensive system of branch lines required in that vast empire. While many countries are thus in a state of indecision on this subject, Norway finds herself free from this difficulty, thanks to her engineer, Carl Pihl. For as we mentioned some time ago, the main lines in Norway are chiefly laid with the 3 ft. 6 in. gauge.

Norway, indeed, is the only country where the narrow gauge system of railways has been efficiently carried out, for there the old school of costly construction was quickly superseded by a more advanced system, in which the adaptability was the one first consideration. Mr. Pihl may be fairly considered the apostle

of this new school, for in no other country have cheap railways been adopted as a standard, and even in those places which we have already quoted as having introduced, or which are now introducing, narrow gauge lines, the distance which the rails are placed apart appears to be the ruling consideration, whereas, in reality, this is but one of the many items that go to make up the total of cheap railway construction. Benefiting by the experience in the sister country, Sweden has to a limited extent availed itself of the results of Mr. Pihl's work, and 3 ft. 6 in. gauge railways have been in operation there for some time. But the standard gauge, nevertheless, is the ordinary one of 4 ft. 8½ in., and the whole of the prolonged discussion ostensibly relates to the question whether it is advisable to complete the main railway system of the country to the standard width, or whether it would be preferable to adopt a cheaper construction and a narrower gauge for the comparatively short length yet remaining to complete the system of main lines.

It is difficult to imagine so protracted a discussion upon so simple a problem as the one immediately involved, and it is therefore only fair to consider that it bears reference to the general rather than the special question.

Doubtless it is a grave error to establish an extravagant system of railway construction, but once adopted and developed to a large extent, the error would be more serious to make a broken gauge, and the first outlay that would be economized would be speedily swallowed up in the various expenses which would be incurred, to say nothing of the various and constant inconveniences imseparable from such a change. Mr. Elworth, an engineer upon the Swedish Government railway staff, and one of the chief champions of the uniformity of gauge, takes unnecessary pains to establish his case, and advances figures which are based upon somewhat obscure data, to prove that a saving only of £477 a mile would be effected by building to the 3 ft. 6 in. instead of 4 ft. 8½ in. gauge. And this saving he proceeds to demonstrate would speedily be consumed for the separate rolling stock required, the independent shops, and engine and carriage sheds, the distinct management, and the cost of shifting loads from the line of one gauge to that of another, and a loss altogether of more than £25,000 on the proposed extension would be the result. Without caring further to inquire into calculations which cannot be considered fair, we need only consider the question of expedience with regard to breaking the gauge in the main system of Swedish railways, and every argument tells against the advocates of these views Mr. Elworth opposes. The narrow gauge railways of Norway are amply sufficent for the traffic requirements of that country, and will continue to be so, till the uncertain future shall have brought with it largely increased demands, when further expenditure for additional accommodation will be justifiable. And equally so with Sweden ; but as its railway system was established before the days of narrow gauge lines, there remains nothing for it but to continue them of the same width. But not in the same manner, and taking example by Mr. Pihl, the Swedish engineer before alluded to, he addresses himself in the right way to the task of making the best of existing circumstances. He knows that a 4 ft. 8½ in. gauge does not necessarily involve a great outlay in original construction, and he very clearly demonstrates that by the adoption of light rails, of minimum formation width, of cheap stations, in fact, of all the elements which together compose a cheap railway, whatever may be its gauge, the standard system may be kept intact, the outlay may be kept down, and that Sweden may complete the Upsala-Storvik line with no fear for the result.

With the secondary system, however, matters stand very differently, and the advocates of the 4 ft. 8½ in. gauge could scarcely hold their ground. For the most part these lines would have a purely local importance, effecting no junction with the main railways, and, as a rule, they would be built as a development of the mineral wealth of the country, which must be idle and useless until means are provided for its transport. We have already stated that Sweden abounds in rich iron ores, and that she could—the means of transportation being provided—place an unlimited quantity at low prices at the disposal of our steel manufacturers.

To effect this a number of cheap independent railways would be required, connecting the mines with the coast, and it

is toward the construction of these that public attention is being specially directed in Sweden. For they are more important than the completion of the State main railways, seeing that the future commercial prosperity of the country is dependent upon its mineral wealth and upon that alone. Sweden cannot ever become the seat of a large iron manufacture, for the cost of fuel forbids such a result; and it only remains, therefore, for her to transport her ores to a market where they will find an inexhaustible demand, and which would at once confer prosperity upon herself and lend invaluable aid to the industry which year by year must assume larger proportions—the manufacture of Bessemer steel.

Diverging, therefore, from the comparatively unimportant question of gauge for the State railway shortly to be set in hand, the great discussion which even now is earnestly going on in Sweden, is embracing the general question, and while at the same time that private enterprise to serve private ends is energetic in its efforts to promote the wealth of the country, the Government has before it a higher and a more comprehensive duty, in stimulating and assisting those endeavors. The great importance of action is acknowledged, the means to be taken are no longer problematical, and Sweden has for her nearest neighbor a country from which she can gain experience, and whose railway system is even at the present time being officially inspected with reference to its adoption in India, where cheap narrow gauge railways are now acknowledged to be all-important.

ON A NEW APPARATUS FOR REDUCING CHLORIDE OF SILVER.

By A. LIBIUS, Ph. D., Assayer to the Sydney Branch of the Royal Mint.

[From "The Artizan."

In the refinage of gold bullion by Miller's new chlorine process, the silver contained in the alloy thus treated is eliminated from the latter in the state of argentic chloride, which, by a subsequent process, is reduced to metallic silver.

This reduction has always been effected in the usual manner, viz., by placing the slabs of fused argentic chloride between plates of wrought iron or zinc, with the addition of acidulated water. Although a perfect reduction to metallic silver has always been achieved, yet it required a considerable amount of time and manipulation, since the thick slabs of fused argentic chloride were, after two or three days, only partially converted into metallic silver, and had to be re-arranged in order to expedite their complete reduction. Such manipulations, however, were not only found to be very objectionable on account of the time they required, but more so on account of the very disagreeable work which they caused to the operator. The reduced spongy silver was broken up by hand into small pieces, in order to ascertain its complete reduction, and was then boiled in acidulated water to free it from iron or zinc.

It remained, therefore, a desideratum to effect the reduction of the fused masses of argentic chloride in a manner which would, at the same time, be quicker in its execution, and also obviate the just-alluded-to manipulations.

In 1868, Messrs. De la Rue and Hugo Müller, in London, constructed a galvanic battery, one pole of which consisted of fused argentic chloride the thickness of a goose quill, the other pole of cylinders of zinc. Adopting this principle, I have endeavored to construct an apparatus which should fulfil the requirements before referred to.

After operating successfully with a small model which allows the reduction of about 250 oz. of argentic chloride in one operation, I have, with slight modifications constructed an apparatus which will reduce from 1,400 to 1,500 oz. of argentic chloride in twenty-four hours. The apparatus and its dimensions are as follows:—

Two thick boards, 15 in. long, are joined together on both ends by three strong battens, so as to form an open box without a bottom, 13 in. long by 14 in. wide, and 15 in. high (inside measurement). The two boards forming the length of the box or frame contain seven vertical

grooves, $\frac{1}{2}$ in. wide, and $\frac{1}{2}$ in. deep, at intervals of $1\frac{1}{2}$ in. from each other. These grooves are cut down to a length of 12 in., leaving 3 in. of each board forming the legs of the frame.

At the termination of these grooves passes horizontally a narrow slit, $\frac{1}{2}$ in. deep, and along the whole length of each board, into which a strip of metallic silver, $\frac{1}{2}$ in. wide and the thickness of a threepenny-piece, is tightly fixed, projecting on one side of the frame about 18 in. beyond each board.

The seven grooves already alluded to are for holding zinc plates, $\frac{1}{2}$ in. thick, 14 in. long, and 12 in. high, which rest on both sides on the strips of silver, which, as just described, are jammed horizontally into the sides of the two boards. A connection is thus established between the seven zinc plates and the strips of silver.

The second part of the apparatus consists of a wooden frame, cut out of a solid board 1 in. thick, and supplied with two large iron handles. This frame is the same length as the box holding the zinc plates, but 3 in. narrower. It contains on each side, parallel to the direction of the zinc plates, 12 slits $\frac{1}{2}$ in. long, which hold silver bands $\frac{1}{2}$ in. broad and the thickness of a threepenny-piece. These silver bands are passed through the slits in the board, so as to form on each side of it six loops, $11\frac{1}{2}$ in. in length and $\frac{7}{8}$ in. wide. The six loops on one side are exactly opposite to those on the other side of the board, at a distance of about 9 in. They are intended to hold the slabs of argentic chloride, which are 12 in. long, 10 in. high, and about $\frac{3}{4}$ in. thick, and are put through these loops lengthwise, projecting on each end about 1 in. beyond the silver bands.

The whole frame holds, as before stated, six of these slabs of argentic chloride, which are placed between the six spaces formed by the 7 zinc plates, from which latter they are about $\frac{1}{2}$ in apart on each side.

The projecting horizontal strips of silver jammed into the sides of the lower frame are then connected with the ends of the silver forming the loops in which the argentic chloride is suspended, and the whole apparatus thus charged is placed in a tub filled with water. After a short time galvanic action is discernible; the liquid gets gradually warmer, and a strong galvanic current is observed. After about 24 hours the action has nearly ceased, and the whole argentic chloride is found to be completely reduced to metallic silver, which retains in the silver loops the same shape, and, outwardly, also nearly the same appearance as when first introduced as argentic chloride. The latter contains always more or less chloride of copper, eliminated together with the silver during the operation of refinage by chlorine, which is reduced together with the chloride of silver ; in fact, this soluble chloride of copper helps to act as an exciting liquor for the battery. In the first experiments, a weak solution of salt (chloride of sodium) was used as exciting liquor ; but it was found that this could be dispensed with, and only common water used. The action, however, is in this case a little retarded, and does not become powerful until about two hours after the battery is set. By using a part of the resulting liquor from a previous reduction of argentic chloride and which contains chloride of zinc, it has been found that the galvanic action sets in very rapidly, and accelerates thereby the completion of the reduction.

No acid is used, and therefore the amount of zinc used in each reduction has invariably been found to be almost the theoretical quantity required to combine the chlorine of the argentic chloride treated with the metallic zinc, in order to form chloride of zinc

The quantity of metallic zinc thus used was always from 24 to 25 per cent. of the weight of the argentic chloride reduced.

The reduced silver is boiled out in acidulated water, in order to remove the basic oxy-chlorides, and finally in pure water, while still suspended in the silver loops. As soon as it is taken off the last boiling, it is immediately ready for the melting pot, since the heat from the boiling water dries the porous mass of silver sufficiently to allow of its immediate melting. The seven zinc plates, when first used, weigh about 140 lbs. avoirdupois ; the six slabs of argentic chloride, of the dimensions already given, weigh about 1,400 oz. troy.

The zinc plates are used over again, until too thin for that purpose, when they are re-melted, and cast into new plates. It has been found that the quantity of zinc

used is little, if at all, increased by prolonging the time of connection with the silver plates after the reduction is completed ; the whole apparatus, when once set in operation, can therefore be left to itself until it is found convenient to melt the reduced silver.

While this apparatus reduces the argentic chloride much quicker than if the latter is simply placed in contact with zinc or iron plates, it obviates any handling of the argentic chloride from the time the latter has been placed in the silver loops until the reduced silver is ready for the melting pot—advantages which have been fully appreciated by those who formerly had to resort to tedious and disagreeable manipulations.

NATURAL AND ARTIFICIAL PRODUCTIONS OF CHINA.

From "The Mechanics' Magazine."

Notwithstanding that the united French and English armies have penetrated to Pekin, and that the plenipotentiaries of both countries maintain their court in that distant capital, very little is really known of the resources, the industries, and the natural wealth of the once famous land of Cathay. Some of our own countrymen have given us much information respecting this ancient country, and recently M. Stanislas Julien and M. Paul Champion have published a work reviewing the whole subject, which is full of interest and not altogether void of instruction. Some day or other that vast empire must acknowledge the power of steam, and substitute railways for its present canals ; and it is worth while to briefly notice what return it can make, what guarantee it can offer, for the investment of capital on large and extensive works. Among its mineral resources the Flowery Land can number the precious metals as well as those of the baser description. Gold is found native ; also associated with iron pyrites, as occurs in Brazil and in the beds of some of the rivers. The river King-cha kiang fully deserves the classic epithet "flavis." It rises in the distant mountains of Thibet, and, after a circuitous route, "pours down its golden sand" in the province of Yun-nan. With the exception of the washing process, the Chinese appear to be ignorant of the art of extracting gold from any matrix with which it may be associated. They distinguish the different qualities by their color, and class them accordingly. Thus the red, which is chemically nearly pure gold, is designated by the number ten ; the yellow by eight, and the greenish by seven or seven and a-half. For testing gold they still have no other method than the old and somewhat uncertain touchstone. The suspected specimen is rubbed with the stone, and then placed in contact with some warm sulphur. If pure, it preserves its color, but if it becomes tarnished it is owing to the presence of silver or copper. This test is both imperfect and ambiguous. As frequently happens in Oriental countries, silver is more plentiful than gold in the Celestial Empire ; and the working of the mines is an Imperial privilege, only conceded at the price of a heavy royalty. A Government agent assays the metal and fixes the price to be paid for the concession, which is roughly proportionate to the intrinsic value of the ore. The silver is found in various combinations with other metals. Thus there is the argentiferous galena, a common ore in most countries ; also silver in combination with copper, antimony, sulphur, and arsenic. The methods of extraction closely resemble those practised by ourselves, and the metal is procured in a state of tolerable purity. From the southwestern provinces of China comes the whole of the tin used in the country. It is classified under the two divisions of mountain, and river or stream tin, the latter of which is the purer and the more esteemed. As an alloy the Chinese fully understand the value of this metal, and render it malleable by the addition of a certain quantity of lead, a process which is carried to an extent that often leads to frauds upon the inexperienced.

M. Champion states that in a work consulted by him, bearing the date 1637, there was no mention made of zinc, or Japanese lead, as it is called. It is therefore presumable that the metal was not known anterior to that period. It is much valued for its alloying powers, and

Canton boasts of supplying the substance in its greatest purity. There is one application of arsenic in vogue among the Celestials which deserves notice. Through its means the young and tender roots of plants are preserved from the attacks of field mice and other vermin, and it not only protects them also from damp and insects, but exercises a favorable influence upon the growth of the plant and the yield of the crop. It is recorded in "The Book of Mountains and Seas" that copper, either native or as an ore, exists abundantly in 437 mountains throughout the empire, and principally in those situated towards the East. The sources being so abundant, it is but natural that the different ores should be equally numerous. There is nothing worth recording respecting the Chinese treatment or employment of this well-known metal, unless it be the alloy, of which their barbarous gongs or tam-tams are constructed; 24 parts of copper and 20 parts of tin compose the mixture which imparts to them their peculiarly disagreeable properties. We recommend the proportions to those gentlemen who are racking their brains to produce some novel noises for the next pantomimes. It should perhaps be mentioned that the beautiful azurite and the mottled malachite are among the varieties found in the manifold mountains. With the exception of the extreme primitive nature of the tools and appliances used in the smelting, casting, manufacture, and subsequent conversion of the raw material into wrought iron and steel, the principle of the various processes is nearly identical with that prevailing among ourselves to within the last 15 or 20 years. The best steel is made from the magnetic oxide, which is tolerably abundant in some parts of the empire. It is well known that the superiority of the Swedish metal is due to the same cause, possibly enhanced by the use of wood for the fuel. In the manufacture of mirrors, the Chinese follow the method handed down from the year 700 A. C. These ornaments, both in China and Japan, are formed of a metallic plate having the composition of copper 50.8 parts; tin, 18.5; zinc, 30.5; and lead 2.2; the total making up a hundred parts. After being brought to a high state of reflective brilliancy, the surface is covered with an amalgam of tin, lead, and mercury in the respective proportions in a hundred parts of 69.36, 0.64, and 30.00. These mirrors lose their polish in a few months, especially if exposed to any sulphurous emanations, but can be easily repolished at a trifling cost. Among natural curiosities may be mentioned the tallow tree, which furnishes by the bruising of its fruit a limpid oil of considerable purity. Th manner in which the Celestials turn out their candles is amusing, and decidedly ingenious. The everlasting bamboo is, as usual, in requisition. One of them is split longitudinally, the pith extracted, a wick placed in the hollow, and the two halves then tied together with strips of osier. A cylindrical mould is thus obtained, into which a quantity of melted tallow, procured from the tree of that name, is poured. So soon as it is quite cold, the two halves of the divided bamboo are again separated, and *la chandelle est fabriquée.* To prevent the candle sticking to the mould, the latter is well moistened by a short immersion in water.

One of the most widely known and extensively used products of Celestial manufacture is unquestionably that of the celebrated Indian ink, or, as it should be correctly called, "*encre de chine.*" Had we the space to spare we would willingly describe the process in detail, but must content ourselves with observing that the real secret of the art lies in the preparation of the lampblack, which forms the principal component. So famed are the Chinese for their lampblack that, although their island neighbors, the Japanese, manufacture the same article, yet they yield the palm to the former, and the richer class among them never use their own homemade ink, but import it from the main land. The author mentions several tests for distinguishing Indian or Chinese ink of a superior quality from that which is inferior; some of these are known to most of our professional readers, but there are one or two which are rather novel. Thus it is not generally known that a stick of good Indian ink may be known by its sound, when struck gently on a hard body. If it be of good quality, the sound will be clear, with a slight ring in it. On the contrary, if the sound be flat and dull, it is a sign that the composition is not homogeneous, and the quality inferior. Like wine, the older the ink the better, and the best is always the heaviest. There are some pieces existing in the

Emperor's palaces which may be truly said to have been preserved from time immemorial, the date of their manufacture having been lost in the oblivion of past ages.

In a matter so nationally important as that of agriculture the Chinese have always maintained the foremost rank, without a single exception. The cultivation of land is there carried to a perfection which throws us "barbarians" completely in the shade. The visitor to the Celestial realms cannot fail to be forcibly impressed by the appearance of the fields through which he passes. Everywhere there is the evidence of the highest agricultural skill and solicitude in the disposition of the farms, the ingenious processes adopted for protecting, fostering, and bringing to maturity the fruits of the soil; and, above all, in the means devised for insuring a constant and abundant supply of water for purposes of irrigation. In this respect we might well take a leaf out of John Chinaman's book. No matter what may be the distance of the fields from the source of supply, or the physical difficulties to surmount, they are invariably successfully overcome, and the fertilizing fluid pressed into the service of the farmer. All the various soils in China are classed under one or other of two great divisions. They are either rich and fertile or poor and barren. The former frequently possess so great a power of fecundation that a portion of the plants grown thereupon are developed to an extent which seriously interferes with the progress of. the remainder. This contingency is provided for by mixing the soil with some of the poorer description, not so well endowed by nature with prolific elements. By the employment of proper manures the soil belonging to the second class is brought into a condition which enables it to grow large and excellent crops. In the application of these manures among the Chinese, practice and experience supply the want of scientific knowledge and refined chemical analysis. They have compensated for the absence of theory by a profound, patient, and long-continued observation, and have produced remarkably successful results by using discretion in the choice of their manures and varying them to suit the particular crops under cultivation. A brief enumeration of the principal manures will at once show the attention paid to the matter. There is, of course, the ordinary farm-yard manure, taken direct from the farm and distributed over the land. Sometimes this is mixed with human and animal excreta, allowed to ferment in a brick tank until it is "done," and then used immediately. A third fertilizer is prepared in small enclosures made of reeds, very appropriately termed by the natives "dunghouses." A collection is made in these receptacles of cinders, rice balls, dried leaves, excrementitious matter of all kinds, and other *debris* of an organic nature. In the preparation of this manure it is to be particularly noticed that the floor of the "house" is on an incline, so that all water may be drawn off. It is also covered with a roof or large lid to prevent the action of the wind and rain. A few days suffice to render this mixture an excellent manure. For the cultivation of China grass *(Urtica nivea)* a very similar fecundator is employed, only it contains in this instance a large proportion of waste water that has been used for culinary and domestic purposes, so that the whole mass is of a thick, semi-fluid consistency. There are also certain crops and plants which are grown by the aid of "burnt manure." A large heap of the various preparations already enumerated is set on fire, the ashes collected, and mixed and sown with the seeds of the plant. By the addition of beef bones to the stable or farm-yard refuse, and submitting the mixture to a long boiling, what is called "boiled manure" is obtained. The ground is watered with this liquid, and the Chinese regard it as one of the most efficacious fertilizers in their whole category. There is no doubt that the action of the boiling water conduces to a minute subdivison of the organic matter, and the gelatinous particles of the animal bones. The properties of lime are well known to the Chinese, who mix it with other ingredients. As a rule they seldom employ a single manure, but give the preference to a mixture of different kinds. They have two proverbs applicable to agriculture. The first is that "manure should be managed like gold," and the second, "it is cheaper to manure the land one has than to purchase more." The sewage of towns is utilized by collecting it in earthen pits placed near the fields or main roads, drying it roughly, grinding

it, and distributing it over the land. Sometimes the waste water from rice and dwellings is allowed to mix with the excreta, and after a short stay in reservoirs, employed in irrigating the fields, either by means of open drains or usually by buckets. The manner of irrigating the rice fields is similar to that known among us as the catchwater system. While advocating the principle of utilization of sewage which is universal in China, it must not be supposed the same means would answer with us. Buckets are the ordinary implements of distribution, and the pits in which the fecal matter of every village is collested are of the rudest construction and very imperfectly closed. The odor is of a most repulsive nature, although the Celestials scarcely seem to notice it. We may certainly imitate that principle, but we must Anglicise the *modus operandi.*

Space will not allow us to more than allude to the most prominent of all the Chinese preparations, that of tea. In the interest of our fair readers it must be stated, although we regret to dispel agreeable illusions, that they are very much mistaken if they imagine they ever drink the "real thing." Neither the Chinese nor the Japanese drink the same kind of tea as we do, nor in the same manner. On the contrary, a particular description is prepared for exportation, and very little of any other kind ever comes to France, England, or America. It may not be generally known that an excellent oil, fetching a very high price, is obtained from the berries of the tea plant, which has the reputation of never turning rancid. A considerable number of women are employed in the tea trade, their daily earnings averaging about 8d. per diem. The hand labor is very onerous, but lately MM. Glover have introduced some mechanical improvements, which are under trial. It has been asserted that there is no nation, people, or even tribe under the sun which is unable to prepare some description or other of an intoxicating liquor. Our Celestial friends are no exceptions to this assertion, and manufacture a national eau-de-vie from rice, sorgho, and other grain. At Han-Keow there is a distillery on a large scale, which the author was permitted to inspect. He mentions that the products are impregnated with an oily taste exceedingly disagreeable to any but native palates. The best paid and best cared for workmen in China are considered to be those who are employed in the silk manufacture. They are lodged, fed, and paid at the rate of 8½d. a day, the whole expense to the master being estimated per head at 1s. 7d. per diem of 12 hours' labor, from 6 A. M. to 6 P. M., allowing an hour for meals. The masons at Han-Keow receive from 4½d. to 5½d. and two meals a day according to their ability. At Pekin out-door labor only lasts during 8 months of the year, in consequence of the severity of the winter, the thermometer falling frequently to 15 deg. below zero. In the other months the diurnal working hours number 8½, but there is not the same regime and discipline among the Chinese workmen as among ourselves. The former "knocks off" work just when he likes, indulges in tea and tobacco, and then recommences a condition of affairs not exactly suited to the temperament of Western employers. As an example of this Oriental intermittent arrangement we may notice the hours observed in a large establishment at Pekin, commencing at 6 A. M. An hour is allowed for breakfast at 7.30 A. M.; at 10 A. M. ¾ of an hour is devoted to the little indulgences already mentioned; the second meal abstracts an hour at midday; and at 3.30 P. M. another ¾ of an hour is appropriated to a similar object as the first. Curious as this style of working may seem to us, it may be very justly remarked that some allowance must be made for the influence of the climate and the physical organization of the men. While on the one hand a Chinaman can exert for a short period a degree of muscular force which no one would anticipate from his comparatively frail appearance, he is incapable of prolonged exercise. Frequent interruptions in his toil appear to be indispensable to him, at any rate in his native country. A perusal of the history of China proves indisputably that the inhabitants are people who for ages have shut their doors against the advent of strangers. Time may possibly break through these barriers, but, judging of the future by the past, the development of the resources of that vast kingdom must be accomplished by other agencies and other heads and hands than those which have allowed them to remain *in statu quo*, it may be truly said, from generation to generation.

WATER—GOOD, BAD, AND GOOD ENOUGH.

From "The Building News."

The Royal Commission, of whom Sir W. Denison is chairman, and Dr. Frankland and Mr. John Chalmers Morton his colleagues, say that absolutely pure water is not to be found in nature. Even at the moment of its condensation in the atmosphere from invisible vapor to visible cloud, water absorbs gases, and when it falls to the earth as rain it percolates through strata or flows over surfaces in some degree soluble, and dissolves quantities of solid matter varying from 3 lbs. to 50 lbs. in every 100,000 lbs. of water. The Commissioners give the following as the chief characteristics of unpolluted water: "It is tasteless and inodorous, possesses a neutral or faintly alkaline re-action, rarely contains in 100,000 lbs. more than $\frac{1}{2}$ lb. of carbon and $\frac{1}{10}$ lb. of nitrogen in the form of organic matter, and is incapable of putrefaction even when kept for some time in close vessels at a summer temperature."

This water may be spoiled in its passage to the sea in many ways, which may be brought under two general heads, "Sewage" and "Manufacturing Refuse." Sewage is a very complex fluid. A large part of its most offensive matter is human excrement, and also urine thrown down gully holes; but, mixed with this, there is the water from kitchens containing vegetable and animal refuse, and that from wash-houses containing soap and the animal matters from soiled linen. There is also the drainage from stables and cow-houses, and that from slaughter-houses. In fact, say the Commissioners, sewage cannot be looked upon solely as human excrement diluted with water, but as water polluted with a great variety of matters—some held in suspension and some in solution—but both present in such a condition as to render it impossible, in the present state of our knowledge, practically to cleanse and purify sewage so thoroughly as to make it safe for drinking even when largely diluted with unpolluted water.

A great deal of the manufacturing refuse is passed into the sewers as the readiest way of getting rid of it, and then it merely adds other ingredients to those already passing down them; but where the manufactories are situated on or near a stream, and the water made use of in the process of manufacture is afterwards transferred directly to the river, polluted by admixture with the special matters used in the different processes, such refuse matters can be treated separately as manufacturing pollution. These may be classified thus: Pollution by dye, print, and bleach works; by chemical works; by tanneries; by paper making; by woollen works; and by silk works.

Of the different kinds of pollution affecting rivers, animal organic matter as it occurs in sewage is that which renders water not only most offensive to the senses, but most likely to injure health both by its gaseous emanations and its, deleterious effects when used as a beverage. Rivers so polluted frequently contain from 1 lb. to more than 2 lbs. of organic carbon, and from $\frac{1}{3}$ lb. to $\frac{2}{4}$ lb. of organic nitrogen, in 100,000 lbs. Pollution by vegetable organic matter, such as that caused by dye and print works, stands next as regards offensiveness, water so polluted being excessively unpleasant not only to the sight, but in warm weather to the smell. It often contains twice as large a proportion of organic carbons as sewage water does, but owing to the smaller proportion of nitrogen in vegetable substances it rarely contains more than $\frac{1}{3}$ lb. of organic nitrogen in 100,000 lbs. of water.

Chemical works contribute chiefly mineral impurities, which often communicate to water extreme hardness and other disagreeable and even poisonous properties.

Having reviewed the remarks of the Commission on good water and bad, let us see what they say in respect of rendering polluted water good enough to be allowed to flow into any river or stream from which it is not intended to take water immediately for domestic use. The prohibitory standard is as follows:—

(1). Any liquid containing, in suspension, more than three parts by weight of dry mineral matter in 100,000 parts by weight of the liquid.

(2). Any liquid containing, in solution, more than two parts of weight of organic carbon, or $\frac{3}{10}$ part by weight of organic

nitrogen, in 100,000 parts by weight of the liquid.

(3). Any liquid which shall exhibit by daylight a distinct color when a stratum of it, one inch deep, is placed in a white porcelain or earthenware vessel.

There are other stipulations which apply more particularly to certain manufacturing towns, but as applicable to towns in general the above are the most important ones.

This standard can be attained, say the Commissioners, by the present known methods of filtration, either through soil in the way of irrigation or through filter beds. The Commissioners regard the irrigation of land with town sewage in a different light to that in which it has been usually regarded. They say that the purification of sewage by irrigation takes place when it passes *through* the soil to a considerable depth, and not merely, as has been often said, by running over its surface. The Commissioners find that the filtration of sewage through either porous soil or sharp sand has the same effect in purifying it that irrigation has; that is to say, it purifies it to a degree which makes it admissible into rivers or other streams such as we have mentioned. The only difference between the two processes, viz., simple filtration and irrigation, is that the former is not remunerative, while the latter is so. Of course, the advisability of adopting one or the other method will depend in any town on the facility for acquiring land for the purpose of irrigation. Where that can be done at a reasonable outlay it is the better method, but where land cannot be had the other method claims attention.

It is curious that, so many attempts to filter sewage having failed, this simple method of dealing with it should be the one at last recommended by the Royal Commission; but when we consider the manner in which such attempts have been made, it is clear that it is not filtration that has been wrong, but the mode of filtering. There are three ways of passing water through a filter-bed—(1) horizontally, (2) upwards, and (3) downwards. Both the former methods have been tried and have failed, for good reasons given by the Commissioners; the latter method, however, is the one they find to effect a purification of the sewage. When water or sewage is passed upwards or sideways through sand or other filtering material, the interstices become full of liquid but devoid of air; whereas, by downward filtration, after shutting off the sewage from one bed and turning it on to another, and so on alternately, which would be the method adopted in practice, the air follows the last of the sewage down into the sand, and thoroughly permeates it; and when sewage is again turned on to that bed it encounters air in its descent and becomes oxidized or purified to the degree recommended by the Commissioners as admissible into rivers. It is not difficult to see why this latter method should be so much better than either of the others. By this method the matter held in suspension in the sewage is arrested on the surface, where it can be easily got at for removal, while by the horizontal method the solid matter lodges amongst the filtering materials and fouls it, and by the upward method the same matter lodges underneath the filter-bed, and is difficult to be got at for removal, besides the inconvenience resulting from the lighter particles of it being carried up into the filtering materials and fouling them.

The inquiries into the pollution of rivers in Lancashire were expected by the Commission to result in some practical conclusions upon the influence of such rivers on the health of the people, and questions were addressed to all the municipal bodies and Boards of Health within the Mersey and Ribble districts, whether the river, stream, or canal passing through or by their town was a source of ill-health or discomfort; and having before them the opinions of the authorities on this subject, and having also the actual statistics of mortality within their respective jurisdictions, and information on the density of population, on the number of cellar dwellings inhabited within the place, the provision of water-closets and privies, the sufficiency of the water supply, and other points bearing generally on the health of the people, and having made themselves acquainted with the condition of the running waters throughout the district, the Commission are not able to say whether the liability to ill-health in any town is influenced by its proximity to a filthy river. This is partly owing to the incompleteness of the health statistics laid before them; but, besides this, it was with astonishment the Commissioners found

that Boards of Health in several large towns, and many smaller ones, were not able to inform them of the death-rate within their districts, still less to give them information of the health within particular divisions of those districts.

ON THE MANUFACTURE OF IRON AND STEEL BY DIRECT METHODS.

(*Continued from page* 241.)

The cost of producing a ton of iron blooms directly from the ore, by the bloomary process, varies greatly with the price of the dressed ore, which will depend on the proximity of the mine to the forge, and the richness of the crude ore. Thus, the cost of the two tons of dressed ore employed to make the fine iron of the Ausable forges, was estimated by Mr. Rogers, in 1868, at not less than \$18.00, while the one and a-half tons of ore consumed at New Russia would not probably cost more than one-half that sum. The following estimate made by a highly competent iron-master, in 1868, may serve as a guide to the cost of producing iron at that time in New York :—

2 tons of ore	\$10 00
300 bushels of charcoal at 8c	24 00
Wages	9 00
General expenses	3 50
Cost of the ton of blooms	\$46 50

The above prices are in American currency, which, at that time, was equal to about $\frac{80}{100}$, making the gold-value \$37.20. The estimate of another manufacturer, in Clinton county, gave \$7.00 for wages. It will be observed, moreover, that the amount of charcoal, in the above estimate, exceeds the average consumption for the production of a ton of blooms, which may be taken at about 270 bushels.

To produce a ton of blooms from cast-iron, in what is known in Sweden as the Lancashire hearth, there are consumed, according to an authority cited by Percy, 23 cwt. of pig-iron, and $\frac{9}{10}$ tons of charcoal. In New Jersey and Pennsylvania the conversion of the pig-iron is, for some purposes, effected by a somewhat similar process, which involves two operations, the melting in the running-out fire, and a subsequent treatment in the sinking-fire, as it is called, which is a bloomary forge very like that used for the ore in the direct method. To produce a ton of blooms in this way, there are consumed 24 cwt. of pig-iron, and 100 bushels of charcoal, according to one authority, while another estimate gives 120 bushels ; the quantity varying both with the quality of the crude metal, and the charcoal ; while, with some arrangements, the consumption of fuel is much greater. The mean of these, 110 bushels, at 18 lbs. to the bushel, would give almost exactly $\frac{9}{10}$ of a ton, the amount used in Sweden. The quantity of charcoal consumed for the production of a ton of pig-iron in the United States varies greatly, but in the best constructed and more modern furnaces, like those of Michigan, with rich ores, will not exceed 130 bushels of charcoal of the above weight, which gives for 24 cwt. of pig-iron 156 bushels. This, added to 110, equals 266 bushels, the total amount of fuel required to produce a ton of blooms by means of the blast-furnace with the charcoal-finery. There would appear to be but little difference, so far as the consumption of the fuel is concerned, between the cost of producing bloom-iron by the direct and indirect methods just described. The first cost of the establishment for the former is, however, less, and this is probably one of the reasons which has led to the adoption of the direct method by the bloomary forge in Northern New York.

The conversion of the oxide of iron to the metallic state, under the influence of solid carbonaceous matter, or reducing gases, takes place at a temperature considerably below that at which the affinity of silica for the oxide of iron is exerted. Even the compound of titanic acid with oxide of iron is decomposed at a red heat in contact with hydrogen gas, the iron being wholly reduced to the metallic state. If it were possible to effect this reduction, and subsequently to eliminate the silica and titanic acid from the metallic iron, ores containing these impurities might be made available for the direct method of conversion ; but the practical difficulties

of effecting such a separation are such that the only available modes of treating such ores as contain considerable amounts of these impurities, are to smelt them in the blast-furnace with proper fluxes, or to effect as complete a separation of the impurities as possible, before submitting them to the process of reduction. This, in the case where heavy granular ores are mixed with quartz and feldspar, as for example, at the Palmer ore-bed, already noticed, is attained by washing away the lighter materials. Where, however, the impurity is chiefly titaniferous iron, as in the Moisie sands, the separation may be readily effected by means of magnets, a process which is equally advantageous where magnetic iron ore is mixed with lighter impurities, as quartz or silicious minerals.

The use of magnets for this purpose has long been taken advantage of, and various machines with permanent and with electro-magnets have been contrived. A simple and ingenious arrangement for this end, which has been invented and patented by Dr. F. A. H. Larue, of Laval University, Quebec, appears to be novel in the mode of its working, and is very efficient and cheap. The mixed sand or crushed ore is poured through a screen, into a hopper, the discharge of which is so arranged as to open and close at proper intervals of time, and falling from this, is spread in a thin and uniform layer, upon a series of aprons arranged, with interspaces, between two parallel endless bands, which pass over two horizontal cylinders. These aprons, charged with ore, are made, by the movement imparted to one of the cylinders, to pass from beneath the hopper, and under a series of permanent horse-shoe magnets, 800 in number, each capable of sustaining about 5 lbs. weight, arranged upon transverse bars, in 5 rows of 160 magnets each. Beneath these is a tympan, covered with muslin, which, when the iron ore is passing beneath them, is in the contact with the poles of the magnets. So soon, however, as the magnetic portions of the ore have arranged themselves, by magnetic attraction, in adhesion to the under side of the tympan, and the apron has moved from beneath, and gone forward to discharge the non-magnetic portion of the ore at the foot of the machine, the tympan is momentarily withdrawn a short distance from the poles, and the adhering magnetic ore falls in the open space between two aprons, into a receptacle placed below. This process of loading and unloading the magnets can be repeated twice in each minute.

These machines, as now constructed, occupy a space of about 6 ft. by 5, and are 4 ft. high; they are said to cost, at Quebec, about $500 each. One of these dimensions will, according to Dr. Larue, treat in an hour 3 tons of sand holding one-third of magnetic ore, separating from it 1 ton, containing over 99 per cent. of magnetic grains. I have myself seen only a smaller machine, the first one constructed, which had a capacity of about ½ that just stated. The motive power required is very small, and the mechanism, as will be seen from the description, exceedingly simple. Dr. Larue observes, that, inasmuch as a rich sand may be passed through the machine as rapidly as a poor one, the yield is directly proportionate to the amount of magnetite present, so that a sand containing one-fourth as much as that above mentioned would yield about 6 tons of purified sand in 24 hours. Even very poor sands may, probably, with this machine, be treated with advantage. The same process of purification may doubtless be applied with advantage, after crushing, to the preparation of lean massive magnetic ores for the bloomary fire, or for other direct methods for conversion into iron and steel. A process of partial reduction, at a low red heat, will render non-magnetic iron ores attractable by the magnet, a reaction of which Chenot long since proposed to take advantage, for the purification of such iron ores as are not naturally magnetic.

In accordance with the well-known fact that the reduction of oxide of iron takes place at a temperature very much below that required for its subsequent carburation and fusion, it has been shown that the charge of ore in a blast-furnace is converted to the metallic state some time before it descends to the zone in which melting takes place. It forms, when reduced, a spongy mass, readily oxidized, which, by proper management, can be compressed and made to yield malleable iron, or, by appropriate modes of treatment, may be converted into steel. This fact has been the starting-point of a great number of plans designed to obtain mal-

leable iron and steel, without the production of cast-iron and the employment of the processes of puddling and cementation. This, it is true, is attained in Catalan and bloomary forges, but the attention of many inventors has been, and still is, directed to the discovery of simpler, or at least of more economical methods of obtaining similar results. A short sketch of the various new processes will not be without value, as bearing upon the utilization of the iron ores of Canada, and especially of its iron sands.

Of these, the method of Chenot is best known. His experiments seem to have been commenced about 40 years ago, since we are informed that he had erected a large furnace for the direct treatment of the ores of iron, in 1831, although his results were not brought before the public until 20 years later, at the International Exhibitions of 1851 and 1855. I was a member of the International Jury at the latter, and had an opportunity of studying Chenot's process as then conducted, on an industrial scale, at Clichy, near Paris. A description by me of the process as then and there practised, will be found in the report of the Geological Survey for 1855–57. Rich peroxide ores were broken in small pieces, mixed with a portion of charcoal, and placed in large vertical rectangular muffles or retorts, enclosed in a gas-furnace, and heated to redness. The ore, after being reduced to the state of metallic sponge, passed downwards into an air-tight cooling-chamber, which was a continuation of the muffle, and when sufficiently cooled, was withdrawn. The spongy metal, thus obtained, was then exposed to a welding heat in a proper furnace, and formed into balls, which were afterwards treated like the balls from a puddling-furnace, and gave malleable iron. By impregnating the metallic sponge with oily and tarry matters, and afterwards expelling these by heat, a sufficient amount of carbon was fixed in the metallic sponge to convert it into steel. By grinding, compressing, and melting this carbonized sponge, cast-steel of a superior quality was manufactured at prices which, it was claimed, were much below the cost of steel prepared by cementation of bar-iron. This process was subsequently introduced in several places in France, Belgium and Spain, where it was applied to the manufacture of bar-iron, and up to 1863, at least, was worked on a considerable scale at Baracaldo, in Spain, where, in 1859, about 10 tons of iron were manufactured daily from iron sponge.

A very important modification of the process already described, in which the heating was effected externally and indirectly, consisted in the internal or direct method of heating. In this the outer furnace and the admixture of charcoal with the ore were both dispensed with. The vertical reduction-chamber was filled with ore only, which was reduced by the action of currents of heated carbonic oxide gas, obtained by forcing air, at a pressure equal to half an inch of mercury, through 2 generators filled with ignited charcoal. This mode of producing the sponge was found much more economical than that by indirect or external heating. The working results of the direct method, as carried on at Lamarade, in Spain, in 1863, are given by Percy; from which it appears that for the production of 1 ton of blooms, there were consumed 1.87 tons of charcoal. The greater part of the fine Swedish iron used at Sheffield for the manufacture of steel, is produced from charcoal made pig, treated in a charcoal-finery, known as the Lancashire hearth, and is obtained with a consumption of charcoal, which, for the united processes of reduction and refining, amounts to 1.90 tons for the ton of blooms, a result almost identical with that of the process of Chenot. (Percy, "Metallurgy," pp. 342–596.) The modified Catalan forge, and the American bloomary fire, as we have seen, produce malleable iron with a consumption of charcoal which is not very much greater, and with a simpler, and probably less expensive apparatus than that required for the Chenot process; while the method by the blast-furnace permits of the use of ores which are unfit for treatment by any of these direct processes.

The patents granted to Clay, in England, in 1837 and 1840, were for the manufacture of malleable iron by a process essentially the same with Chenot's earlier method of indirect or external heating. According to Clay, hematite ores were mixed with one-fifth of their weight of charcoal, coke, or other carbonaceous matter, and heated to bright redness in a clay retort, or other suitable vessel, until the ore was converted to the metallic state. When the reduction was complete, the

spongy iron (without previous cooling, as in Chenot's plan) was transferred directly to a puddling-furnace, where it was brought at once to a welding heat, made into balls, and then wrought into blooms in the usual manner. This process was tried on a pretty large scale near Liverpool, in 1845–46, and although iron was regularly made by it for some time, and to the amount of 1,000 tons, the process was not found to be commercially profitable, and was abandoned.

The process of Renton, patented in the United States in 1851, was very similar in principle and mode of working to that of Clay. The mixture of ore and coal was introduced into a vertical muffle or retort, which was inclosed in the flue or chimney of a furnace, not unlike an ordinary puddling-furnace. The contents of the muffle, being sufficiently heated, were reduced to the metallic state, and, from time to time, discharged from the bottom, into the furnace, where the spongy iron was exposed to a welding heat, and wrought into blooms. This process, after having been essayed on an industrial scale at Cincinnati, and at Newark in New Jersey, was abandoned. A similar fate attended the trials, on a large scale, of Harvey's patented process, at Mott Haven, near New York, about the same time. In this, the coarsely powdered ore, mixed with charcoal, was placed on inclined trays or shelves of steatite, in a heated chamber connected with a welding or balling-furnace. The flame from a fire below was made to pass through the chamber, and the ore, being at length reduced to the metallic state, was transferred to the hearth below, and there converted into blooms. For a farther description of these various processes, and the similar plan of Yates, the reader is referred to Percy's "Metallurgy," pp. 330–348.

Chenot's plan of reducing the ore by a current of carbonic-oxide gas was adopted by Gurlt, who used the direct mode of heating, already noticed. The gases from the generators charged with fuel, were led through flues, into the vertical reducing-chamber, a blast of air being at the same time introduced into the flues, in sufficient quantities to keep up the combustion of the gases. By this means, according to the specification, "there passes into the shaft a mixture of flame and carbonizing and reducing gases, by which the iron ore is heated" and carbonized. According to Gurlt's patent specification (No. 1679, London, July 16, 1856), by continuing, for a sufficiently long time, the action of the gases, the resulting iron sponge may be more or less carbonized, so as to yield, by subsequent fusion, either cast-iron or steel. These partially carbonized products he proposed to melt in a reverberatory gas-furnace, the blast of air into which is to be "so regulated that it exactly burns the gas produced in the generators," and that neither unburned gases nor unconsumed air escape; the object being to obtain a neutral flame, which should not alter the sponge upon the hearth. In this way carbonized sponges from rich ores, are said to have been successfully converted into cast-iron in Spain.

Gurlt's ingenious specification thus involves the idea of first reducing the iron ore to a metallic sponge, and afterwards carbonizing this sponge, so that, by subsequent fusion, it may be converted into cast-iron or steel. Although the conception of thus carbonizing the iron while in a spongy state, is probably novel, the use of carbonaceous gases or vapors for carbonizing iron, and converting it into steel, is not new, as may be seen from the patent for this purpose granted to Macintosh in 1825. The experiments of Percy upon iron wire have also shown the rapid carbonizing effect of coal-gas and heavy oily vapors, like those of paraffine ("Metallurgy," pages 109 and 773); and, according to Marguerite, carbonic-oxide gas, at an elevated temperature, yields up a portion of its carbon to iron, which is thus converted into steel. Practical difficulties have hitherto prevented the application of hydro-carbon gases and vapors to the carbonizing of bar-iron on a large scale.

With the results of Chenot, Gurlt, and Macintosh before us, we are prepared to understand the process of Dr. George Hand Smith, of Rochester, New York, which is just now attracting some attention in the United States, for the production of steel. The crushed and purified ore, or iron sand, mixed with a portion of pulverized charcoal, is heated in a kind of reverberatory furnace, with an arrangement which permits the vapor of petroleum of coal-tar to pass through the mass, thus aiding in the reduction, and finally carbonizing the resulting sponge, which

is then transferred to a puddling-furnace, to be wrought into iron, or, if properly carbonized, into steel.

Before proceeding farther, mention should be made of some other methods which have been devised for the treatment of iron sands, and for their conversion into iron or steel. In 1851 a patent was granted to Stenson, for a process for working the iron sands of New Zealand, and similar ores from India. These were to be mixed with small portions of clay and lime, with or without the addition of charcoal; the mixture was ground in a pug-mill, with water, and formed into lumps, for subsequent treatment in the blast-furnace. In 1862, Moreau proposed to mix iron sands with iron filings or turnings, and then incorporate them with fuel, such as peat-coal or coke; the mixture being made into blocks, which were to be smelted in suitable furnaces. In 1866, Mr. James Hodges, who was not acquainted with the experiments of Moreau, moulded the iron sands of Moisie into blocks with peat, and by treating these, after drying, in a proper furnace, succeeded in converting the ore into malleable iron, at a single operation.

Messrs. Whelpley and Storer, of Boston, effect the reduction of the iron sand ore, or pulverized ores, on the hearth of a reverberatory furnace, which is heated, in part, by pulverized coal, borne by a blast of air over the fire of solid coal upon the grate. In this way the furnace-chamber is filled with a volume of burning coal-dust, which can, by regulating the supply of coal and of air, be made either oxidizing or reducing. The heated ore upon the furnace-hearth is thus reduced to the metallic state, balled and made into blooms, with, it is claimed, a great economy of fuel.

It has also lately been proposed to convert these sands into steel or cast-iron, by melting with a sufficient admixture of charcoal in crucibles, or other closed vessels, heated from without. This is, in fact, nothing more than an extension of the dry method for assay of iron ores. A patent for making steel in this way, by treating rich ores, mixed with carbonaceous matter, in air-tight melting-pots, was granted to Lucas, in 1791, and a similar claim was made by David Mushet, in 1800; while, according to Percy, "experiments in the direct production of cast-steel from iron ores, in crucibles, were made by Riley, at Dowlais, a few years since, and although excellent steel was occasionally produced, it was not found possible to insure uniform results."

More recently, Ponsard has brought forward a similar process, the results of which were communicated to the French Academy of Sciences, July 19, 1869. This arrangement consisted of a number of fire-proof crucibles about 8 in. in diameter and 40 in. high, which were placed in a reverberatory gas furnace, the mouths of the crucibles being fitted into openings in the furnace-roof, for convenience of charging. The lower part of the crucible is perforated, and rests on the sole of the furnace, which is furnished with gutters leading to a depression or basin in the middle of the furnace-hearth. The crucibles are charged with the ores, mixed with proper fluxes and about 12 per cent. of carbon, sufficient to effect the reduction and carburation of the iron, which, under the influence of a very intense heat, melts, and, running through the holes in the bottom of the crucible, collects in the basin in the middle of the furnace. According to Ponsard, a ton of coal is consumed for each ton of iron produced, so that the process cannot be recommended for its economy of fuel. He, however claims as a great merit of this process, the complete separation of the fuel from the carbon required for the reduction of the ore, so that for the furnace, inferior kinds of combustibles, which, if brought directly in contact with the ore, would injure the quality of the metal, may be used with safety and advantage.

The process patented by Johnson, January 22, 1868, as described in the "Practical Mechanic's Journal" for June, 1869, is, however, exactly similar, in all its details, to that of Ponsard, which was first announced as a novelty to the French Academy, July 19, 1869, 18 months later. In a specification dated at Quebec, July 16, 1869, Dr. Larue claimed, and subsequently received Letters Patent for Canada, for a process similar in design to that of Johnson, of which he was ignorant. Although there were differences in detail, the avowed object in both plans was to separate the ore, with the carbon required for its reduction, from the fuel (which might, consequently, be of an inferior quality), and to permit a continuous charging

and discharging of the crucible. The difficulty of constructing sufficiently refractory crucibles for the intense temperature, and the small yield to be expected from such a process, would perhaps prevent it from ever being used for the manufacture of cast-iron. Dr. Larue, however, anticipated its application to the production, not of cast-iron, but of cast-steel, which would require a very nice adjustment of the proportions of carbon to secure a uniform quality in the product; as in the ancient processes of Lucas and Mushet, and the more recent experiments of Riley, mentioned by Percy, and referred to above.

Two processes for the production of steel are those which depend, respectivly, on the combination of cast-iron in proper proportions with malleable iron or iron sponge, and with oxides of iron. In the specification of a patent granted in 1839, Heath claimed the production of steel by melting with cast-iron, either wrought-iron, or oxides of iron or manganese. In a second patent, granted to him in 1845, he described an arrangement by which the cast-iron was kept in a molten condition, in a gas-furnace, while pure iron in scraps, or in sponge, obtained by reducing oxide of iron, as in Chenot's and Clay's method, was added from time to time; until, by trial, the proper quality of metal had been obtained, after which the liquid steel was run into ingots. Other processes, based on the reactions embodied in Heath's first patent, are those of Uchatius (patented in 1855), who melts granulated cast-iron in crucibles, with a certain proportion of oxide of iron, and thus obtains a fine quality of steel (a process already specified in Wood's patent, in 1761); and that of Brown (patented in 1856), who, to produce steel, melts, in crucibles, mixtures of pig-iron and clipped bar-iron. This method is practised to some extent in Sweden, where it is known as the Obersteiner process.

In the process of Obuchow, which appears to be successfully used in Russia, fine pig-iron is melted, and run into a large crucible, previously heated to whiteness, and holding magnetic iron ore, alone, or with titanic iron sand and iron and steel scraps. The crucible is then heated till the contents are perfectly fluid, some nitre and arsenious acid are added, and the steel run into ingots. By a somewhat similar process to this, Ellershausen attempted to produce steel, by pouring molten cast-iron upon previously oxidized sheet-iron, heated to redness, and placed in a heated vessel. The oxide dissolved in the molten iron with violent chemical action, decarbonizing it, and producing a kind of steel; but it would probably be difficult to effect a thorough conversion of the iron without keeping up the heat from without; which was not done in Mr. Ellershausen's first experiments, made in Montreal, in the spring of 1868.

The above processes, however, involve the use of crucibles, and it had become a great desideratum to produce cast-steel upon the open hearth. This was the aim of Heath, in his process described above; but the difficulties in producing and controlling a heat sufficient for the purpose, were so great as to render the efforts in this direction but partially successful, until the regenerative gas-furnace of Siemens placed in the hands of metallurgists the means of fusing large bodies of steel on the hearth of a reverberatory. Provided with this, the Messrs. Martin, of Sireuil in France, have succeeded in producing cast-steel, in charges of three and four tons at a time, by melting down wrought iron in a bath of cast-iron, by what is known as the Siemens-Martin process. The products thus obtained attracted much attention at the Paris Exhibition, in 1867, and the process has since been widely adopted in Europe and in the United States; where it was first introduced by Messrs. Cooper, Hewitt & Co., and is now in successful operation at their works at Trenton, New Jersey.

Beginning with a bath of 6 cwt. of pig-iron on the hearth, malleable iron, as puddle-bars, for instance, is added, previously heated to whiteness, and rapidly dissolves in the molten cast-iron, until, at the end of about four hours, the charge amounts to three tons, and will be found to consist of a soft, nearly decarbonized metal. It is then recarbonized by the addition of from 5 to 8 per cent. of spiegeleisen (manganesian cast-iron), as in the Bessemer process, and run in moulds. The bath of molten metal, during the process, is protected by a covering of fused slag or cinder.

The furnace-bottom for this process is made up of a silicious sand, which must not be quite pure, but contain some alu-

mina or other bases, so that, under the influence of the high temperature, it may harden, without melting, forming an impervious crust, which will resist for a considerable time the action of the molten steel. The upper part of the furnace is built of Dinas fire-brick. Attempts have been made to use an admixture of oxide of iron with the pig-metal in this process; but it is found that the corrosive action of the oxide, at a high temperature, upon the furnace-bed is such as to preclude its employment. The entire cost of a furnace with a capacity of producing three tons of cast-steel, with gas-producers, generators, and all the apparatus for moving the ingot-moulds, is, in England, about £500 sterling.

This process, it is true, cannot compete with the Bessemer or pneumatic method for the cheap production of cast-steel in large quantities ; but while the latter is applicable only to certain fine kinds of cast-iron, comparatively free from phosphorus and sulphur, the process in the open hearth permits the employment of other qualities of iron: These, in being reduced, by puddling or otherwise, to the condition of malleable iron, are deprived of the impurities prejudicial to steel, before being added to the iron bath. While, therefore, the Bessemer process will probably remain without a rival for the treatment of the purer cast-irons, the production of steel by the open hearth will perhaps become even more important, because of wider application. The Heaton process, for which so much was claimed as a method for the production of steel from impure cast-iron, by the action of nitrate of soda, appears, from the late careful studies of Gruner, destined to become sudsidiary to the production of steel in the open furnace. Gruner concludes that it "can never, from any point of view, become a substitute for the Bessemer and Martin processes. These produce ingots of steel, or homogeneous iron, from pure brands. The Heaton process deals with impure brands, and seeks to convert them into a refined metal, more or less purified, the treatment of which has to be finished in a Siemens furnace." He further declares that the only advantageous way of treating the products of the action of nitrate of soda on cast-iron, is to submit them to the Siemens-Martin process.

Mr. Bessemer has very recently made experiments upon the working of his process under pressure, by which he obtains such an elevation of temperature as, it is expected, will enable him to introduce malleable iron into his converters, and thus effect in them what Martin does upon the open hearth. In the mean time Siemens has, by the aid of his furnace, been able to carry out a part of the original plan of Heath, who, in 1845, proposed to reduce iron ores, by heating them, in small fragments, with charcoal, in a close vessel, as in the methods of Chenot and Clay, and to add the resulting spongy iron to the bath of molten cast-iron. The reduction is, by Siemens, effected by a plan which combines the indirect and direct methods of Chenot.

Above the furnace, and immediately over the bath of molten cast-iron, which occupies the hearth, are two large tubes of refractory clay, enclosed in an outer casing, through which the flame from the furnace passes, and allows these tubes, or reduction-chambers, to be heated, with their contents, to redness. They are charged from the top with finely broken rich ore, through which a current of previously washed and purified carbonic oxide gas, from the common gas-generator of the furnace, is forced, and reduces the ignited ore to the condition of a metallic sponge of pure iron ; this, descending, is at once dissolved in the molten cast-iron bath, and effects its conversion to steel precisely as in Martin's plan, where solid malleable iron is made use of. In certain cases, as with very finely divided ores, the reduction is effected by an admixture of about 10 per cent. of charcoal, or other carbonaceous matter.

Siemens has already manufactured excellent cast-steel by this method, and there is no doubt that, in the case where pure oxides, free from sulphur and phosphorus, can be obtained, the mode of directly producing steel with spongy iron may be advantageously employed.

A simple and ingenious process, based, like that of Siemens, on the original suggestion of Heath, has recently been devised and patented by Mr. Robert G. Leckie of Montreal. Having found that when finely-divided iron ore, as magnetic iron-sand, was made into lumps with peat, coal, or other carbonaceous matter, not in excess, and exposed to redness, out of a

current of air, there results a nearly pure spongy metallic iron, he proposes to obtain iron in this way, and add it to the bath of molten cast-iron, in a reverberatory gas-furnace. The ore, agglomerated with the reducing material, is to be placed in one or more large chambers or ovens, in the rear of the hearth, and, when sufficiently heated to effect its reduction, is to be added to the bath of molten iron. He expects soon to test, on a working scale, this mode of making cast-steel in the open hearth, to which the purified magnetic iron sands of Canada, from their freedom from sulphur and phosphorus, would seem to be peculiarly well adapted.

It is one of the great advantages of the Siemens furnace, that by a judicious regulation of the supply of air, and by proportioning it to the gaseous fuel, it is possible to obtain, at will, either an oxidizing, a reducing, or a neutral flame ; a point of much importance in the fusion of metals in the open hearth, which was already indicated in Gurlt's specification.

The employment of gaseous combustibles has been greatly extended since the successful use of the regenerative principle by Siemens. This consists in allowing the heated gases, after combustion in the furnace-chamber, to pass out, downwards, through two chambers packed with fire-bricks, so arranged as to allow a free passage of air between them, to which they impart their heat ; the waste gases passing off into the stack at a temperature seldom above 300 deg. Fahr. After an interval of from half-an-hour to an hour, the current is changed, and the gases are led off through another pair of regenerators ; while those which had been heated by the escaping gases are now used to conduct the air and gas for keeping up the combustion ; these passing in through the heated regenerators, have their temperature greatly raised before entering the combustion-chamber. By alternately making each pair of regenerators the channels for the passage of the gases to be burned, and for the waste products of combustion, a very intense temperature is maintained in the chamber, with very little loss of heat.

Coal and dry wood have generally been used in the gas-generators, where, by partial combustion, the solid fuel is converted into combustible gases. With wet fuel, a large amount of steam becomes mingled with the gases, where its presence is very objectionable. This difficulty has, however, been entirely obviated by a system lately devised in Sweden, which may become of great advantage to Canada. I have therefore thought it best to copy from Mr. Abram Hewitt's Report on the Production of Iron and Steel at the Paris Exhibition of 1867, the following account of this valuable invention. This report, published by the United States Government, contains excellent drawings of the furnace :

"The furnace devised by F. Lundin, of Carlstadt and Munkfors, is designed for the consumption of turf and peat, without drying, and of wet saw-dust or other moist fuel : an invention deemed so valuable that the Association of Swedish ironmasters have rewarded Lundin by a gift of $10,000, which, in Sweden, is a very considerable sum. In this furnace, the fuel is fed by a hopper, into a reservoir resting upon an inclined grate, supplied from below with air from a blower. The products of the combustion thus maintained, pass through a condenser, where all the moisture in the gas is condensed. The gas then passes to the heating-furnace, which is furnished with Siemens's regenerators."

It is found easy to use fuel holding as much as 45 per cent. of water. The gas, as it issues from the producer charged with such wet fuel, contains one-fourth its weight of watery vapor. It passes at once into a chamber in which, from perforated pipes, small streams of cold water are discharged, crossing each other in various directions, and filling the chamber. By this, the gas is greatly cooled, and the acid and tarry matters present, with much of the steam, are condensed. It then passes through a second chamber, filled with wrought-iron bars, arranged like the bricks in the heat-regenerators, and kept cold by a stream of water trickling over them. The gas, which at the time of its escape from the producer, was heated to the melting point of lead, is thus cooled down until it retains only 4 per cent. of watery vapor.

"The expense of building a full-sized furnace, in Sweden, is about $2,500 in currency, and it is estimated that such a furnace will utilize 1,700 tons of fuel in a year, at a saving proportioned to the cost of other fuel in the particular locality

where it is employed. In Sweden, it is estimated that the annual saving, resulting not merely from the fuel, but from the repairs of the furnace, and the increased temperature, amounts to over $5,000 per annum, on the product of each furnace. * * * * The gas produced by seasoned wood contains more water than that which proceeds from the Lundin condenser. The duration of the furnace is simply surprising, and is to be attributed, probably, to the fact that there is no cinder. In 8 weeks, the thickness of the roof, 4 in., was only diminished from $\frac{1}{4}$ to $\frac{1}{8}$ in., and the side-walls were entirely uninjured. So wonderful is the success of this system of condensation, in connection with the Siemens regenerators, that, in Sweden, and, in fact, everywhere where moist fuel is employed, the Lundin furnace will supersede every other. Its great merit is, that it is available for any kind of fuel whatever. In the United States it is believed that this arrangement might be employed advantageously for washing the gas obtained from mineral coal; but its chief merit consists in the fact that in mineral regions, far removed from the coal fields, it is possible to establish iron works, using saw-dust or peat with entire success and great economy. In the lumber regions of Lake Superior it will be found to have a special value, because there is an abundant supply of pig-iron, accessible to the saw-mills on Green Bay and in Michigan, producing enormous quantities of saw-dust, slabs, and waste-timber."

By the aid of the Lundin furnace, combined with the regenerators of Siemens, Rinman has succeeded in producing steel by the Martin process, using only pine saw-dust for fuel. When such results can be obtained with saw-dust, or with ordinary peat, the want of mineral coal need no longer be an obstacle to the development of the metallurgical industry of this country.

The gas-furnace of Boëtius, which is now used for zinc-smelting, and in many glass-works, in France, is simpler and less expensive than that of Siemens. It does not make use of the regenerative principle, and hence the waste heat can be employed for boilers or for other purposes. In this furnace, however, there being no condenser as in the Lundin system, only dry fuel can be made use of. The air which serves to burn the combustible gases in the furnace-chamber, is heated by passing between the walls of the generator and an outer casing, these walls being made very thin, and supported at intervals by bricks, which are built both into them and their envelope. This furnace does not enable us to obtain a heat sufficient for the production of cast-steel, but is well adapted for puddling and reheating iron, as well as for zinc and glass-works, and is said to economize from 30 to 33 per cent. of the fuel. This description is taken from a paper by Gruner, Professor of Metallurgy at the Ecole des Mines of France, which appears, with working-drawings, in the "Annales des Mines," for 1869, fifth part.

THE iron interest is the principal support of Youngstown, Ohio. The rolling mill of Brown & Bonnell employs 600 men, with a pay-sheet of $40,000 a month; manufactures 500 tons of iron a week into all sizes and shapes, from the smallest nail to the heaviest bar, and consumes 325 tons of coal a week. Shedd, Cartwright & Co.'s rolling mills employ 100 men and boys, pay $7,000 wages monthly, manufacture 6,000 tons annually of hoop and band iron. Two machine shops find active work. The first, that of Homer, Hamilton & Co., uses 1,200 tons of iron annually. Ward & Majorum use 1,000 tons a year of iron, give employment to 80 mechanics, turn out first-class machinery, engines, rollers, and all of that class required by furnaces and rolling mills. Arms, Bell & Co., nut and washer factory, employ 20 men. Park, Stedman & Co. manufacture all classes of bolts, employ 50 men.

THE fall of a large mass of rock between Heidelberg and Weisloch has brought to light the works of a silver mine which was known to the ancient Romans. There is no silver ore of any importance left, but a very rich zinc ore is met with in large quantities.

ENGINEERS are engaged in making a final survey of the Portage and Ripon Railway.

HEAT IN THE BLAST FURNACE.

From "Engineering."

The manner in which the heat developed by the combustion of the fuel in a blast furnace is disposed of, has from time to time been made the subject of various estimates by different metallurgists, and although these estimates differ materially in their details, and although, moreover, no one of them, probably, can lay claim to any very great precision, yet they nevertheless possess considerable interest, indicating, as they do, the direction in which improvements are to be made if increased economy is to be obtained. The more carefully any estimate is made, the greater is its value for the purpose we have named, and we consider that the hearty thanks of our practical iron manufacturers are due to men who, like Scheerer, Tunner, Ebelmen, Bunsen, Playfair, and more recently, I. Lowthian Bell and C. Schinz, have devoted their time and energies to the investigation of the action of the blast furnace, and have endeavored with greater or less success to determine from the practical results obtained, the laws by which these results are governed. It is only those who have conducted such investigations who can thoroughly realize the labor and perseverance required to establish a single fact connected with blast-furnace working. An investigation of the action of a blast furnace is dependent upon a number of other collateral investigations; such, for instance, as the determination of the amounts of heat rendered latent during the liquification of the iron and slags; of the specific heats at different temperatures of the materials forming the charges; of the heat absorbed during the decomposition of the peroxide of iron, and of the limestone; of the losses of heat by radiation, etc., and other kindred matters. More than this, there is considerable difficulty in obtaining correct data as to the performance of any given furnace; the charges and blast contain variable quantities of moisture, and variations also take place in the quantities, temperature, and composition of the gases evolved, which render it necessary that a large number of observations should be made at brief intervals if a reliable average result is to be obtained.

Taking all these matters into consideration, it is not to be wondered at that differences should exist between the estimates which have been made as to the manner in which the heat developed is disposed of in the blast furnace; but we have the satisfaction of knowing that, as reliable data accumulate, these estimates will become more and more reliable, and of greater practical value. We have no intention of entering here into an investigation of the various estimates which have been made by our leading experimenters; but we wish to point out a source of loss of heat in the blast furnace, of which, so far as we are aware, none of the estimates hitherto published take any account. It is usually considered that the heat developed is disposed of in effecting the reduction of the peroxide of iron, the decomposition of the limestone, the fusion of the iron and slags, the decomposition of the moisture in the charges and blast, the heating of the tuyere water, and in supplying the losses caused by radiation, convection, and conduction from the sides of the furnace, and by the heat carried off in the waste gases. That almost the entire quantity of the available heat can be accounted for by these means is an undoubted fact; but there is, nevertheless, at least one other source of loss of heat which appears to us to be worthy of attention. This loss consists in the heat rendered latent during the expansion of the blast from the pressure at which it is supplied to the furnaces to that at which the waste gases issue from the throat. The assumed insignificance of this loss has, we believe, caused it to be generally disregarded by metallurgists; but although we acknowledge that its amount is small, it is, we think, not so small as to render it unworthy of notice, and some very simple calculations will, we consider, show that this is the case.

It was long ago proved by the researches of Laplace and Poisson that if a given weight of any gas was allowed to expand freely whilst it was being heated, a greater quantity of heat was required to raise its temperature any given number of degrees, than if during the heating process the gas was maintained at a constant volume. In other words, the specific heat of a gas

maintained at a constant volume is less than that of the same gas maintained at a constant pressure, the difference between the two specific heats being due to the amount of heat rendered latent during the expansion of the gas. It follows from this, that if a gas heated under any given pressure is allowed to expand to a lower pressure, its temperature will fall, and *vice versa,* the variation in the temperature in the case of air being given by the following formula :

$$T = \left\{ (t + 461.2°) \times \left(\frac{P}{p} \right)^{0.29} \right\} - 461.2°$$

In this formula $t =$ the temperature of the air in degrees Fahrenheit at the pressure p, whilst T is the corresponding temperature at the pressure P. The pressures P and p are measured above a vacuum and may be taken either in atmospheres, pounds on the square inch, or any other convenient unit of measurement—care, however, being taken that the same unit is used in each case. The 0.29th power of the fraction $\frac{P}{p}$ can of course be readily obtained by the use of a table of logarithms.

The manner in which this formula can be employed to determine the loss of heat due to the expansion of the blast in a blast furnace can, perhaps, be best illustrated by an example. Let us suppose, then, the case of a furnace consuming, say, 26 cwt. of coke per ton of pig produced and blown with blast at a pressure of about $3\frac{3}{4}$ lbs. per square inch, or, say $1\frac{1}{4}$ atmospheres, this blast being heated to 1,000 deg. Fahr. Under these circumstances, the quantity of blast supplied to the furnace would be about $6\frac{1}{2}$ tons per ton of iron smelted, and it is the loss of heat due to the expansion of this quantity of blast which we have to determine. At the mouth of the furnace the pressure would, in all probability, be practically equal to that of the atmosphere, so that in passing through the furnace the pressure of the gases forming the blast would be diminished from $1\frac{1}{4}$ to 1 atmosphere. Introducing these quantities into the formula above given, we find the reduced temperature of blast due to the amount of expansion just mentioned to be :

$$\left\{ (1000 + 461.2) \times \left(\frac{1}{1.25} \right)^{0.29} \right\} - 461.2$$
$$= (1461.2 \times 0.9374) - 461.2 = 909.5° ;$$

or, in other words, the mere expansion of the blast would alone cause a diminution of its sensible heat by 1,000—909.5=90.5 deg. The specific heat of air, when maintained at an uniform pressure, being 0.238, the heat rendered latent in the manner just mentioned amounts, in the case we are considering, to $6.5 \times 2240 \times 90.5 \times 0.238 = 313{,}608$ pound-degrees or thermal units ; and, as each pound of carbon consumed in a blast furnace may be taken as producing, on an average, about 6,000 thermal units, the quantity of heat rendered latent by expansion represents the consumption of $\frac{313{,}608}{6000} = 52.26$ lb. of carbon, or say, about half a hundredweight of coke. This quantity, although it forms but a small proportion of the total consumption, is yet, we think, worth taking into account when an estimate is being made of the disposal of heat in the furnace.

It remains to be considered how far the source of loss we have pointed out is likely to be affected by the modifications which are being made in blast furnace working. The tendency of the day is towards larger furnaces supplied with blast at higher temperatures and pressures, and this increase of temperature and pressure will, of course, increase the loss, from the cause we have mentioned. But, on the other hand, the new furnaces require less fuel, and consequently a less weight of blast than those worked with blast at a lower temperature and pressure, and it is probable that this reduction in the weight of blast required per ton of iron will more than counterbalance the increase in the amount of heat rendered latent due to the other new conditions. In conclusion, there is one deduction to be made from the facts we have stated, to which we desire to direct attention, and this is, that the nitrogen contained in the blast acts as an absorber of heat, which is never recovered. Roughly speaking, about 5 tons of the $6\frac{1}{2}$ tons of blast—which we supposed in our example to be supplied to the furnace per ton of iron smelted—would be nitrogen, and the calculation we have given shows that this nitrogen, whilst expanding during its passage through the furnace, would render latent an amount of heat equal to that produced by the consumption of the furnace of about $\frac{5}{6.5} \times 56 = 43$

lbs. of coke. This loss cannot be recovered, whatever may be the way in which the waste gases are utilized, and it is, moreover, a loss which, as it cannot be discovered by the ordinary modes of observation, has been hitherto generally neglected.

THE RIFLING OF HEAVY GUNS.

From "The Engineer."

The strongest argument that the advocates of the Whitworth gun are able to adduce is that the normal, or Woolwich gun, is comparatively inaccurate, liable to damage from the breaking up of shot in the bore, and deficient in range. Few artillerists dispute the fact that these assertions are, to a certain extent true; the system of complete chilling has been abandoned, and only the heads of shot and shell are now cast in contact with cold iron. Projectiles fired from the guns of the Hercules and the Monarch turn heels over head in their flight; one gun in the Hercules has been temporarily disabled. The same fact is true of the gun carried by the little Staunch gunboat, and also of certain guns on board other vessels. The partisans of Sir Joseph Whitworth find in these things ample reason for condemning Mr. Frazer's guns, totally ignoring the fact that Mr. Frazer is in no sense responsible for the system of rifling adopted; while to this last, and to this alone, are due the failures of which they make so much capital. It is now tolerably certain that we are to have a 35-ton gun, although it is still doubtful whether this gun is to be made by Sir Joseph Whitworth or by Mr. Frazer; if by the former, it is not difficult to predict what the result will be; if by the latter, the result will altogether depend on the system of rifling adopted; for there is no reason to doubt that Mr. Frazer possesses both the means and the ability to produce a perfectly sound and trustworthy gun, as far as the question of endurance is concerned. But we want guns which will not only not burst, but will shoot straight; and projectiles which will neither give way in the gun, nor deteriorate by keeping. It is essentially necessary to a proper comprehension of this subject that our readers should bear in mind that the best gun in the world, as far as powers of endurance and cheapness are concerned, may prove a most unsatisfactory weapon if it be rifled on a bad system; and it is difficult to resist the conclusion that all the heavy guns we have now in our possession are defective in this respect. In fact, it is impossible to avoid the conviction that we cannot much, if any, longer continue to rifle guns as we rifle them now. The construction of a 35-ton gun affords an admirable opportunity for introducing something better. That that something is not the hexagonal, erroneously known as the Whitworth system, all but a few artillerists will admit. But opinions, even after the hexagonal system has been excluded, will no doubt differ as to what the rifling of the gun of the future should be. Ours may be plainly expressed in a few words.

In 1864–5 a competitive trial of 7-in. guns, rifled on various systems, was carried out by a select committee. The results obtained have already been published in our columns. They left no doubt in our mind that the best of the systems tried was, taking all things into consideration, Captain Scott's. Nevertheless, the French, or stud system was adopted, and to this stud system all the defects of our modern guns are attributable. We need not at this time describe the difference between the two systems, Scott and French, they must be well known to every one who will care to read this article. The record of events since 1864–5, proves that the conclusions at which we then arrived were correct. The stud system is, for heavy guns, a practical failure. We might occupy pages in explaining why. Among other reasons, it will suffice to say, that the method of construction necessarily adopted renders the shot weaker. The studs are blown off, the projectiles are honeycombed round the stud cavities, the studs themselves are so weak, that they cannot be used with a moderately sharp twist. The shot does not lie fair in the gun at the first, and being imperfectly supported in the chase, it comes out thumping up and down, and not unfrequently jamming and breaking up in the bore. All manner of changes in the

method of placing the studs have been tried, but at this moment it has not been settled how far apart the studs should be, nor how the shot should be balanced on them, nor is it known whether 2 or 3 rows of studs are better than 1 row. All that is known about the matter with certainty is that the French or studded system of rifling has failed to give good results with heavy guns, though it has answered, we believe, moderately well with small field pieces and such like comparatively tiny weapons.

The point to be settled, then, is, What shall the rifling of the gun of the future be? We hold that as no system tried in 1864–5 gave better results than Captain Scott's, that his system should now have a further trial on a larger scale, say with a 10-in. gun. If the results are as satisfactory as, reasoning from analogy, we have grounds to suppose they will be, then let a few more guns be rifled on the same system, and distributed throughout our fleets. In the course of a very few months, if not weeks, it would be known whether the Scott rifled gun possessed the advantages we believe it to possess, advantages which would suffice to justify its general adoption. The cost of the trial would be very small, as our readers will readily understand that it has nothing to do with a new gun, but only with a system of rifling which has already given satisfactory results. Here we have no novel metal, nothing abnormal in the system of forging, or unusual in the nature of the projectiles. Any large service gun, as yet unrifled, can have five Scott grooves cut in it without materially impairing its usefulness as a rifle on any other system, should the Scott system not justify our anticipations. The projectiles are of the simplest and cheapest character, ribs cast on them taking the place of studs let in. An experiment begun now, would, at a nominal cost to the nation, decide a most important point regarding the future of the 35-ton guns which are certain to be carried by our ships sooner or later.

SILTING UP OF RIVERS.

From "The Mechanics' Magazine."

All engineers who have had anything to do with work in connection with rivers and streams are well aware that in the lapse of time very material alterations and modifications take place in their beds or channels. Frequently, the original course of the river is totally changed. Sometimes the bed is deepened by an increased scour, and at others it is rendered shallower by the deposition of foreign particles along its course. The latter is a more frequent occurrence than the former, and is due to both natural and artificial causes, which are deserving of investigation. The nature of the river channel has a very important influence in deciding the amount of silting up to which it may be subjected. Thus, if the river have a rocky bed, it very speedily becomes cleared of any loose earth or sand that may have originally adhered to it, and even supposing a heavy flood to bring down a quantity of mud and small particles in mechanical suspension, the hard rock would scarcely retain them any length of time after their deposition. A very moderate scour would suffice to remove them, and the bed would undergo scarcely any appreciable variation in level. Without the attribution of the fact to artificial causes, a river channel will sometimes become, from natural causes alone, silted up to such a degree that the stream in time of flood cannot find its way along its old course. Under these circumstances, after overflowing its banks and doing an incalculable amount of mischief to the riparian proprietors, it finally cuts out a new channel for itself. It does not always follow that the old bed is altogether abandoned, for in process of time the new course may become also choked up, and the stream will actually return to its original channel. So long as the silting up of rivers is accomplished by natural agency alone, a very trifling amount of dredging will suffice to keep the channel open, and if the bottom be of a sandy or gravelly nature, the state of it will more than pay the expense of procuring it. It may be mentioned that the silting up of rivers is nothing in comparison with that which takes place along the sea coast. The tendency for the bottom to silt up at Har-

wich is so great that the project of a harbor there had to be abandoned in consequence.

Directly we come to artificial causes, the silting up of the beds of rivers assumes proportions far in excess of those resulting from natural ones. Latterly, this has been traced to the enormous amount of liquid and solid pollution which is permitted to find its way unchecked, and, in many instances, unknown, save by its effect, into nearly all our rivers and streams. It may be stated that there is not a single natural watercourse in the country which is not polluted by artificial causes at some part of its course between its source and its mouth. However limpid and clear it may be at the commencement of its journey, it is nearly certain to become turbid, polluted, and contaminated before it arrives at the end of it. It was but a short time ago that it was indisputably proved that the bed of the Thames had been silted up several feet, owing to the enormous quantity of refuse and sewage matter it received from the drainage of the metropolis. Shoals and mudbanks had formed in situations where previously the bed had been smooth and even, and vessels could no longer pass places where they had previously ridden with a foot or two of water under their keels. The evil result of this accumulation of *debris* in the channel of a river is still more apparent when the dimensions of the stream are on a more limited scale than those of the Thames. If we select the Irwell as an example, the immense amount of refuse of every kind annually thrown into it has partially diverted its course in some places, and has raised the level of the bed to such an extent as in flood-time to seriously damage all the adjoining houses and other property. It is easy to comprehend how a diversion of the river is caused by the tilting up of part of the water-way. If a large quantity of *debris* be thrown into the stream from one bank alone, it immediately raises the level of that side of the bottom, and when a rush of water comes down it is driven to the opposite side, and thus endeavors to cut out a new channel in that direction by destroying and undermining the bank, an event certain to ensue after repeated attempts. From careful examinations of the level of the beds of the Irwell, the Irk, and other streams flowing through the large and populous manufacturing towns of Lancashire, the silting up has been found to be at the rate of nearly 2 in. per annum, or 1 ft. in six years. On the other hand, if care be taken to exclude all refuse and foreign substances from the river, the bed will gradually become free from the deposit that may have accumulated previously to the adoption of such precautions. Some years ago the town of Bacup was always inundated by every flood that occurred, but since a stringent prohibition has been put in force against the casting of rubbish into the river flowing through it, the channel has deepened and the houses are dry and safe even in extraordinary floods. The discharge of town sewage, manufacturing and other refuse of every description, may be said to be the cause of the silting up of all those rivers and streams which flow through inhabited localities. In no other country but our own is this wholesale pollution of rivers permitted. France, Belgium, and Prussia have long since legally provided for such contingencies, and punish with a heavy fine the infringement of the law. All manufacturers who produce a refuse of a description likely to impede, pollute, or render undrinkable the water of any stream, are compelled to construct reservoirs or tanks where the necessary subsidence may take place, and the supernatant liquid, if sufficiently pure, may be discharged into the nearest watercourse. The real truth of the matter with respect to the pollution of rivers by manufacturers' refuse is that the manufacturers find it pays a great deal better to make the river the receptacle for their refuse and by-products than to attempt to purify or utilize them. No doubt this is the fact, but still one portion of the community cannot be permitted to get rich at the expense of the lives and safeties of another.

The peculiar purifying action exercised by large masses of running water upon the deleterious and injurious substances they may contain, has long been a subject of remark, also of considerable discussion. It has been asserted by some that after the lapse of a certain time the water becomes completely purified and freed from all the noxious qualities imparted to it. This, it is needless to point out, is an error. That some of the contaminating and polluting qualities do become mitigated there is no doubt; but the longest river in Eng-

land would be incapable, during its whole course, of freeing its waters from sewage and other refuse, supposing it received them at its very source. As only the substances held in mechanical suspension form the deposit at the bottom of the river bed, the silting up of it favors the deposition, as it is easy to show. The particles held in suspension are carried along at a given velocity by the current, sinking lower and lower as they are borne down the stream. The greater the depth they have to fall before coming finally to rest, the longer are they held in suspension. It is thus that shoals accumulate so rapidly, for as they are raised above the bed, they intercept all the particles in transition before they have sunk low enough to reach the lower portions of the river bottom. A repetition of the same cause and effect continues until the shoal assumes such proportions as necessitates its removal or drive the stream to alter its course.

When there is a decided tendency to silt up manifested in the bed of any river, and sewage and manufacturing refuse are discharged persistently and in large quantities into it, there is very little use in attempting to combat it by means of dredging. The task is simply an endless one, and the expense exceedingly heavy, as it is very rare that the filth dredged up can be applied to any purposes whatever, not even for those of manure. While it retains most of its offensive properties, it has lost the greater portion of those which render it valuable as a fertilizer.

When a shoal reaches to such a size that its removal is absolutely necessary, there are one or two different methods of effecting this operation. Sometimes the material is not dredged up, that is, not actually taken out of the river, but disseminated, as it were, over a large area of the bed. Instead of excavating the shoal, and carrying the stuff bodily away, it is merely loosened or disintegrated, and the current then wafts the particles down stream, gradually depositing them in its course. The cubical contents of a shoal, which might be a serious evil when all in one mass, would be nothing when distributed over a mile or two of channel. One advantage of this distributing method is that the expense is comparatively very trifling, but it is of course inapplicable in instances where the current is very slow. A very ingenious machine has been lately used in the Mississippi for the purpose of removing shoals, and is known as Long's scraper, being the invention of Colonel Long, one of the United States engineers. It acts upon the principle just enunciated, and may be briefly described as a steamer provided with a frame containing a number of iron scrapers. Having approached the shoal the frame is let down, the iron scrapers fix themselves in the mass, the steamer gets under weigh and drags them right through it, stirring up and disintegrating the sand and mud in a most effectual manner. When the steamer has cleared the shoal and got into deep water the frame is hoisted up, she steams back again, and the operation is repeated as often as may be required. This invention is likely to be of great use in removing the silt that accumulates at the bar of harbors, where 18 in. or 2 ft. of sand often prevent ships from getting in and out until a very high tide bears them over.

The "Philadelphia Press" says that pure metallic lead is not believed to exist anywhere in a native condition. At all events its existence in that state has always been disputed. Yet a mine of such lead is again announced to have been discovered in Thuringia. Some years ago the same discovery was announced as having been made near Edinburgh, and quite an excitement was created amongst the incipient mineralogists of the good old town. It was afterwards discovered that the supposed native veins of metallic lead were artificial, having been produced by the penetration of musket bullets fired against the rock by a rifle company that had been out for a day's practice.

The Lafayette Iron Company's furnace is about 2 miles from the Terre Haute and Indianapolis Railway, on a branch of Otter Creek. The company was organized in April, 1868, and the furnace went into blast June 17, 1869. The capacity of the furnace is put at 20 tons per day.

An effort is being made to raise stock for the establishment of a farm implement manufactory in Zanesville, Ohio.

WAR AND WATER.

From "The Scientific Review."

That inability to apply the principles of logic, or insufficient confidence in the soundness of those principles, not unfrequenty causes conclusions to be drawn which scarcely follow from the premises, has long been known ; thus, we are told, that in the reign of Abdallah III. there was a great drought at Bagdad, and that, although the Mohammedan doctors issued a decree that the prayers of the faithful should be offered up for rain, the drought continued. The Jews were then permitted to add their prayers to those of the true believers, but the supplications of both were ineffectual. As famine stared them in the face, those dogs, the Christians, were at length enjoined also to pray. It so happened that torrents of rain immediately followed. The whole conclave, with the mufti at their head, were now as indignant at the cessation of the drought as they were before alarmed at its continuance. Some explanation was necessary to the people, and a holy convocation was held ; the members of it came to the unanimous determination that the God of their prophet was highly gratified by the prayers of the faithful, that they were as incense and sweet-smelling savor unto him, and that he refused their requests, that he might prolong the pleasure of listening to their applications ; but that the prayers of those Christian infidels were an abomination to the Deity, and that he granted their petitions the sooner to get rid of their loathsome importunities. Some conclusions about as logical have just been published by Mr. Ch. Le Maout, pharmacist, of St. Brieuc, in consequence of the drought we have recently experienced.

The connection of war and water is perhaps not studied by military officers generally, except so far as relates to the transport of large bodies of troops across seas and rivers ; whilst the conclusion drawn by most non-military persons would be that the discussion of war and water must relate exclusively to naval warfare. If we accept the doctrine of Mr. Le Maout, we shall learn what lamentable results such ignorance may lead to. As Mr. Le Maout is the author of a work entitled "The Cannonades of Sebastopol, or the Cannon and the Barometer," published in 1856, it appears that he has occupied himself for some time with the question ; and he considers that his observations, made during the Russian war, and published at the time, established in an unequivocal manner the condensing action of cannon upon cloud, and consequently their effect upon barometrical indications. This action was constantly observed in Brittany in from 100 to 120 minutes, although the distance from the seat of the war was more than 600 leagues as the crow flies. During the formidable cannonades of the siege of Sebastopol he notices that generally—in Brittany we presume—whenever the firing commenced the azure of the sky was overcast, and a fine rain or mist fell, frequently followed by heavy showers and then by wind. Afterwards, and as a consequence of these condensations, the barometrical column was put in motion, and rose at a speed and to a height proportioned to the extent of the cannonade. The record of the barometrical indications represented pretty exactly the extent of the firing when the effect was not modified by some great physical phenomena, such as a volcanic eruption or a great fire. Then the rarefying force neutralized the condensing force, and the barometer remained stationary until one or the other conflicting forces ceased to operate. But still more marvellous, and what attests the extreme sensibility of the instrument, he observed, that after six memorable engagements, followed by armistices of two or three hours concluded for the burial of the dead, the barometer stopped, and remained stationary during the whole time the burial was going on ; then, just after two or three hours, at the moment when the cannonading recommenced, the column again gave signs of movement upward, and by its speed made up for lost time. It was this remarkable property that enabled him to calculate the exact time that was required for the force applied in the Crimea to exert its influence in Brittany.

And it is not cannon alone that possesses this condensing action. Mr. Le Maout has found that the explosion of mines and powder-mills, and even the sound of bells, produce a similar effect. Even the

simple striking of a village clock, and of those of churches and chapels, suffices, on the coast of Brittany, where they have almost constantly a humid atmosphere, to make the rain fall; but for this, certain physical conditions are necessary. The wind must be blowing from the south-west, and carrying rain-cloud, and the barometer must stand below 76 centimetres. In this state of things, when the temperature is not high, it is rarely that the striking of the hours does not show its condensing action upon the aqueous vapor, especially when the clouds are low, for the vibration of bells and of clocks striking only acts within a limited area. In the month of May, 1856, the year of the great inundations, he carefully observed the exact time of the fall of the rain, and found that, out of 133 times that it rained in the month, the fall occurred 76 times at the striking of the hours, 42 times at the half-hour, 8 times at the three-quarters, and 7 times at the quarter. He considers that it is the intensity of the sound, as well as the repetition, that has the most powerful effect upon the condensation of the vapor of water; and he explains that such observations cannot be made in Paris and other large towns, where so many noises are produced from fortuitous or accidental causes between the times of the striking of the clocks. Speaking generally, he maintains that all noises produced by physical or artificial causes result in the condensation of aqueous vapors. Thus the beating of the drum, and the sound of military music where brass instruments predominate, produce identical effects, and it is the same with heavily-laden wagons passing over paved streets, and with trains of loaded trucks on railways. The vapor of water being formed of myriads of vesicles of the smallest diameter, similar as to their fragility to soap-bubbles, it is not surprising that, by the powerful percussion of the aerial mass, they should break, and resolve themselves into rain. When we are enveloped in this vapor by a sky charged with rain-clouds, we are in a most impressionable medium, which, for its fragility, may be compared to a palace of glass. If, under these circumstances, we fire a cannon, all will be smashed to atoms, and necessarily fall about our ears. If, however, there be nothing above us but the azure of heaven, we may fire cannon and ring as long as we like, yet nothing will fall. "It is this," says Mr. Le Maout, "that the adversaries of my doctrine of condensation will not understand; they wish, as proof of the truth of it, that rain shall fall under all circumstances."

Now, were this the sole objection to Mr. Le Maout's hypothesis, he would certainly have grounds of complaint, for it must be acknowledged that there are many experiments which can only be successfully performed under favorable conditions, but in effect he admits that, whatever may be the conditions, the success or failure of the experiment is dependent upon the merest chance, for he adopts nearly the same argument as was used by Mr. George Shepherd, an English weather forecaster, to account for the fact that no dependence whatever could be placed upon his forecasts. "But," says Mr. Le Maout, "if it does not rain upon us when we fire the cannon, or when we ring, it may rain somewhere else, especially when the sky is charged with rain-cloud within the area affected by the sonorous body. Thus, not only may rain fall in the neighboring village, but even at immense distances, since in the great disturbances of the aerial mass by the formidable discharge of artillery at the siege of Sebastopol it often rained here (in Brittany), although not a drop fell in the Crimea." From this it would appear that our great pharmacist is not so much in want of correct premises as of ability to deal with them; but it is precisely this latter want that gives us the amusing absurdities he has treated us to. "Often," he continues, "the firing of the cannon and the sound of the bells clear the cloudy sky, and send the threatened storm afar."

Similar effects were observed, not only during the Crimean war, but during that of Italy, and of the Austrians and Prussians; and he observes that storms were more frequent than usual during those events. In confirmation of his views he reminds old military officers that at the siege of Antwerp the besieged were constantly under torrents of rain, and up to the knees in mud, but that as soon as the citadel was taken the rain ceased, and the weather became fine. They will remember, too, the memorable storm of hail, rain, and wind, which occurred before four or five o'clock in the evening on the battle-field of Solferino, which alone put an

end to the fury of the combatants, and saved the remnant of the Austrian army. In that case the physical force was accumulated by the powerful means used, which had the effect of concentrating the hurricane upon the battle-field itself, the battle acting incessantly like a suction pump. He accounts for the storm at Puebla and the non-success of French arms in Mexico in a similar manner, and it seems that even England may well be thankful that M. Le Maout's doctrine was not accepted half a century earlier. The success of England in some of her greatest conflicts with foreign nations has frequently been attributed to her knowledge of war and water; and (in another sense it is true) Mr. Le Maout attributes the loss of Waterloo by the French to the want of that knowledge. If, he observes, Napoleon I. had known this condensing power of cannon, which, by the way, he could better than any one else have observed upon so many fields of battle, he would not have undertaken, upon June 16th and 17th (the eve of Waterloo and day previous), the battle of Ligny, and the engagement with the rear-guard of Genappes, during which a storm occurred, commencing about three o clock in the afternoon, and continuing for twelve consecutive hours to pour down torrents of water, which converted the ground into a perfect marsh, alike impracticable to man and beast. It was the twenty-four rounds fired on the retreating English columns that, in Mr. Le Maout's opinion, brought down the rain, and prevented the movement of the French troops until the following day, by which time the Prussians had arrived; hence the loss to the French of the battle of Waterloo.

It is difficult to determine whether Mr. Le Maout is the more worthy of admiration as a philosopher or as an historian; but as we are not called upon to give a decision, the question may consequently be left to our readers. We will content ourselves with explaining how the great discovery is to be turned to practical use, by recording a statement of the conditions which he regards as most favorable to success. The instructions are given for St. Brieuc, so that experimenters will have to make the necessary corrections for locality if applied elsewhere. Make the experiment with the wind blowing from the south-west and carrying heavy rain-clouds, and choose a day when the barometrical pressure averages less than 76 centimetres. Commence in the morning, before the misty bank formed on the surface of the English Channel is dispersed by the rays of the sun. The lower the temperature the better. Proceed by simultaneous explosions from one or several batteries every quarter of an hour. Upon this day all military target practice should be suspended; and if the experiment be made upon the day of a religious feast, when the bells are rung, the probability of success will be all the greater. If the experiment succeed, and it be judged that sufficient rain has fallen, transport the condensation cannons from Cherbourg to Brest, and fire again to stop the current of vapors coming from the ocean by condensing them in their passage. Thus, to have rain, fire at Cherbourg on the rainy winds of the south-west; to have dry weather, fire at Brest on the easterly winds which reach there after having traversed Central Europe, and been deprived of their vapor of water by the numerous bells in Christian churches and the noise of military exercises which they have met with on their way. There is, in Mr. Le Maout's opinion, reason to believe that if the condensation cannons, which act like a suction pump, were kept in energetic motion on the English Channel, the vapor of water would flow there and fall as rain, not only from the west, but from the Mediterranean and the Northern Ocean. Is this to be accepted as a result of superior technical education on the Continent?

If protective tariff is class legislation for the benefit of manufactures, then it will stimulate manufactures, causing manufacturers to employ more men, pay higher wages, consume more agricultural products, and while creating a better demand for the farmers' crops, will lessen relatively the number of farmers who compete with each other in raising them. But as more employment and higher wages are just what all workingmen want, and fewer farmers and higher prices for crops are what all farmers want, the free traders are obliged to deny that protective tariff will in fact aid manufactures. If so, in whose favor is the class legislation?

THE FRICTION OF STEAM ENGINES.

From "The Engineer."

If we did not believe that it is easy to say something new on a subject which has been in a very peculiar sense worn thread-bare by the inventors of cylinder lubricators and steam greasers, this article would never have been written. So far as we are aware, all the information regarding the resistance of steam engines due to friction is to be found in the circulars of inventors, one or two papers read before engineering societies by the advocates of particular methods of lubricating engines, certain theoretical disquisitions contained in text-books of mechanical science, and perhaps a report or two in the "Journal of the Royal Agricultural Society." It is almost needless to say that the subject is one of very considerable importance ; but it may be worth while to bring this importance home in a tangible form to the employer of steam power. It may be stated, in pursuance of this object, that it by no means follows that an engine giving a very high indicated duty per pound of coal is really the most economical that a manufacturer can use, for the simple reason that the power required merely to drive the engine may be so great as to render the saving in fuel valueless. A case in point suggests itself. An experiment was made some time since with a compound engine, the general particulars of which are before us. This engine was of the annular type ; the large cylinder about 15 in., the stroke of both pistons about 35 in. diameter; the inner cylinder was the same, about 5 ft., the piston rods both laying hold of the same crosshead, which was connected with an overhead beam. The experiment consisted in shutting the steam off from the inner cylinder and driving with the outer annular piston alone. It was found that the engine, then indicating the same horse-power as before, failed to drive the machinery at the proper speed ; and it was not till the indicated horse-power was augmented nearly 40 per cent. that the engine would do the work. On permitting the steam to find its way to the inner cylinder as before, the indicated horse-power fell to the original point, the machinery being driven at the proper speed. We shall not pretend to explain why this was the case. It is indeed difficult to understand why the fact that the inner cylinder, though open to the atmosphere, took no steam, should so enormously reduce the effective power of the engine. The facts are as we have broadly stated them, and there is no reason to think they would now want explanation if engineers had in times past devoted a little attention to the study of the phenomena of friction in the steam engine. We have no doubt whatever that many so-called economical engines are doing very bad work indeed ; nor that many so-called wasteful engines as far as coal is concerned, are giving out a far higher duty than is generally believed. The entire subject is wrapped up in mist —a mist which can only be dispelled by careful experiments, extending over long periods, and properly and fairly analyzed. That a few engineers have conducted experiments on the friction of steam engines and other machines is certain ; but it remains to accumulate in a single volume the statistics which these gentlemen possess, and to put them into a form which may render them generally useful. In pursuance of this object we have for some time past been accumulating data, as yet infinitely far from being complete. But these data have, at all events, done this much—they have satisfied us that ordinary theories regarding friction in steam engines based on investigations concerning the coefficients of friction between lubricated surfaces, apply most irregularly and imperfectly. In other words, there is no theory at present in existence which will enable us even approximately to predicate with certainty what the loss of effect by friction in any given engine may be. In certain cases, calculations made with this object will correspond, with surprising exactitude, with the results obtained through the indicator and dynamometer. But the engineer, resting satisfied with such occasional coincidences, is mistaken in his views. In scores of other instances enormous discrepancies will be found to exist between theory and practice—the almost total absence of frictional resistance in some engines contrasting strangely with the expenditure of power absolutely wasted, in others. It is

not the mere loss of fuel alone—although that is bad enough—that has to be considered in dealing with this subject. We find engines unable to do their work overloaded and worn out; boilers burned and overtaxed; grease and oil wasted; indeed, we go so far as to hold that every horsepower unnecessarily spent in overcoming the frictional resistance of a steam engine costs three times as much as if it were spent in doing useful work, and this without taking at all into account the fact that useful work returns money, while what we may term the internal work of the steam engine returns none.

The difficulties which lie in the way of ascertaining by actual experiment what the frictional resistance of an engine is, are very great; and to this cause no doubt is to be attributed the greater portion of the existing ignorance of the subject. The obstacles in the way are of two kinds. In the first place, it is very difficult to put a dynamometer, or brake, on large engines whereby to ascertain their duty; and, in the second place, the amount of friction varies not only in different engines, but in the same engines in a very extraordinary way. As regards the first difficulty, we can, in the case of pumping engines, ascertain precisely how many foot-pounds of work an engine actually gives out in the shape of useful effect, while the indicator shows the work done on the piston; but from these data it is impossible to calculate engine friction exactly, because our calculations are complicated by the greater or less efficiency of the pumps. It is possible that nothing can be more deceptive than the results obtained from pumping engines, and therefore we have no hesitation in rejecting their aid in dealing with questions of engine friction. Practically speaking, the only generally available test is the indicator used with the engine light and the engine loaded; but diagrams taken thus do not account for the extra friction due to the performance of work, though useful to some extent in their way; but no investigation of the qualities of an engine can be regarded as complete unless the dynamometer is used as well as the indicator.

As regards the variation in the loss by friction in the steam engine, a very great deal might be said which we shall not attempt to say now. It may induce others to experiment for themselves, however, if we place a few facts curiously illustrative of the peculiar phenomena of engine friction before our readers. In one case we conducted the experiment personally; for the results of the other we are indebted to a gentleman who, in superintending the replacement of ordinary boilers by the now well-known Howard boiler, has occasion to indicate a very large number of engines and on whose accuracy we can rely with certainty. In the first experiment which we shall cite we found the full power exerted by a rolling mill engine in the North of England—where, it is unnecessary to specify—to be 291.5-horse. This included the resistance due to a fly weighing 30 tons, a bar mill with 2 pairs of rolls working on heavy orders, and the requisite gearing. Engine and mill empty required, according to one set of diagrams, 74.8-horse power to run them at the working speed; but according to another set of diagrams, the frictional resistance of engine and mill is less than 35-horse power, and all the diagrams were taken within a few hours. We cite this case only to illustrate the difficulties engineers have to contend with in endeavoring to estimate the friction of engines under ordinary circumstances.

The other experiment is very interesting and curious as regards results. The engine was a double-cylinder traction engine, built by Messrs. Howard, of Bedford. The cylinders are 8 in. diameter and 12¾ in. stroke. The engine shaft can be disconnected from all the rest of the machinery, so that the whole work done by the steam consists in turning the crank shaft and overcoming the friction of the bearings, pistons, etc. With 60 lbs. of steam in the boiler, the engine making 190 revolutions, indicated unloaded 2.64-horse power. The engine was then set to drive a brake loaded to 16-horse power, the link being put in full gear; under these conditions the engine indicated 22.55-horse power. The frictional resistance was therefore increased by the fact that the engine was now doing work, to 6.55-horse power, or to nearly three times that of the unloaded engine. This is all plain sailing, but now comes a most remarkable fact. The throttle valve was thrown full open, or nearly so, and the engines linked up—that is, worked expansively at the same velocity, 190 revolutions per min. The load on the brake, etc., remai nng

absolutely unaltered, any engineer would predict that, under these circumstances, the result would be the same ; far from this being the case, however, it was now fond that the effective work or duty of the engine being unaltered, the indicated power *was only* 19.86-*horse power*, so that the friction of the engine when linked up was only 3.86-horse power, or a little more than one-half that of the engine working in full gear. Lest there should be any mistake about this, the brake was then loaded with 504 lbs. With the link in full gear the engine indicated 44.88-horse power ; the link was then put in the first notch, and the throttle valve fully opened, everything else remaining unchanged, when the power fell to 40.92-horse, the frictional or internal resistance of the engine in the latter case thus being 3.86-horse power less than in the immediately preceding experiment. How are these facts to be accounted for? Is it that the varying strain on moving surfaces in contact, due to the action of expanding steam, is attended with less frictional resistance than is present when the metals are under the steadier strain of non-expanding steam? We shall not pretend to answer these questions. These are the facts for the consideration of those interested.

Is it too much to hope that engineers who have the opportunity, will take up this subject, and endeavor to throw light into what is at present a very dark and unexplored region of mechanical engineering? We are convinced that the results would, when time and perseverance had multiplied data, be found of very great value to those who desire to see the steam engine undergo the real improvement of which it is still capable. We venture to suggest that the general practice of indicating the engines tested by the Royal Agricultural Society while running against the brake, and the publication of those diagrams, would be productive of much good. Suppose the society begin at Oxford?

STEAM ROAD ROLLING.

From "Engineering."

A report upon the economy of road maintenance by steam rolling, written by Mr. F. A. Paget, printed by order of the Metropolitan Board of Works, and now going through its second edition, is likely to do good service in bringing about a most important and extensive reform. And if we do not compliment Mr. Paget so much as *Punch* has done, by calling him a Colossus of Roads, we at all events congratulate him for having taken much pains in gathering information and placing it in a useful practical shape upon the matter of economy in road construction and maintenance. Information of this sort is especially hard to obtain, for as the metropolitan streets belong to a great number of parishes, and as all these parishes are looked after by a number of vestrymen, who have their own independent notions of doing business or pretending to do it, it will be readily understood, that parochial statistics are hard to glean and too often not worth much after they are obtained. Mr. Paget, indeed, hints at this difficulty in introducing the compendious table at the end of his report, a table presenting the mileage area, and cost of maintenance of the various macadamized roads within the metropolis. But although somewhat imperfect, this table, as well as the statistics which are plentifully scattered through the report, form an ample basis upon which to prove the advantages of steam over that of horse rolling, or of vehicular road adjustment. To the mechanical mind, the question scarcely admits of argument at all, and the pity is that, for the most part, those under whose control the metropolitan roads are placed would require the aid of a surgical operation before the value of Mr. Paget's arguments could be got into their heads. The vestries, however, we believe and hope, hold the Board of Works in much esteem, and though that latter body has set but a poor example in employing horse rollers only upon the Victoria embankment, we trust this report, printed "by order," may have due weight.

In the proper construction of a macadamized road, three distinct interests have to be consulted—that of the rate payers, that of the public, and that of the cattle employed upon such roads.

There is (we quote the figures from the report) an average sum of £781,000 spent yearly by the thirty-nine local metropolitan governments, upon the various roads and streets, of which about £280,000, is devoted to the maintenance of 1,126 miles of macadamized thoroughfares. There are horses and vehicles of an approximate value of £4,000,000, using these roads, and yet scarcely a step has been made in the right direction towards making a good road first of all, and then preserving it in the most suitable condition for the traffic. The time has come for a change in these matters, however ; and if vestries are too slow or too obtuse to discharge those duties with which they are intrusted, other and more comprehensive powers will at last be compelled to act for the general good, and sweep aside the various petty powers that now exist chiefly to perplex.

Setting out of the question granite paving, the great cost of which renders its universal application impossible, but which, nothwithstanding the inconvenience arising from the noise it creates, and the insecure foothold it affords, is the noblest, most enduring pavement in the world, the problem of construction and maintenance with which we have to do refers exclusively to macadamized roads.

Every one is unfortunately familiar with the aspect of roads newly covered, or repaired, with the layer of small broken granite, every fragment of which lying loosely with regard to its fellows presents sharp edges to the feet, human and bestial, that come in contact with it ; every one is familiar with the piteous spectacle of laboring horses toiling with painful steps over the cutting surface, with the draught of the load behind them increased threefold, and the difficulties of progress infinitely multiplied ; every one is familiar with the sight of horses fallen upon the cruel stones, and with all the inconvenience, the difficulty and pain, inseparable from the use of such a roadway. By slow degrees this rugged surface becomes more easy; it takes months sometimes, however, with the pressure of horses' feet, with the action of wagon wheels, until a portion of the road is made comparatively fit for travel, to the neglect of the rest, and this portion, unduly used, may often be seen worn hollow, or cut into ruts, while the stones lie untouched upon another part. And here it is as well to note that—so says Mr. Paget—parochial deference exhibits itself in a custom of renewing macadam towards the fall of the year in London, so that poor men's beasts may smooth the way for rich men's cattle when the season comes.

But, on the other hand, it is not so common to see a road properly laid down and fit for traffic before traffic is turned upon it. Let us take the latest instance that has become beneath our notice—that of a portion of the Wandsworth road. There were the same preliminaries for relaying, the old road taken up, the new formation laid down, the same layer of broken granite, and then the steam roller—one of Messrs. Aveling & Porter's 15-ton rollers. Over the rugged surface it worked to and fro, compressing the fragments beneath the weight of its broad cylinder, not crushing them so much as turning them over upon their broadest surface, until, with each succeeding pressure, the intermediate spaces became smaller, the stones were more closely packed together, and the interstices being filled with grouting, the rollers went to and fro, bringing the surface into shape, consolidating, giving it a firmness and a surface which traffic could never do. And this in a few days. Or take the evidence of Mr. J. Newlands, borough engineer to Liverpool, who has been working Aveling's road roller for two years and a-half or more. He finds "that besides its advantages in making a newly-coated macadam road perfectly smooth in a single night, it is of no less utility in forming the foundations of new roads. Formerly the traffic had to be turned on these foundations to consolidate them and render them fit to receive the protective coatings of paving or macadam respectively, a work which took from 3 to 6 months, according to the locality. Now, when the foundation is laid, it can be rendered fit for paving and macadam in a day or two." We could multiply instances in support of these views, if it were necessary, for it would be indeed strange if, amongst those who have power over our roads, there were not a few who formed an exception to the general rule of ignorance or indifference. And with these indisputable proofs in favor of steam rolling, which remove the advantages derived entirely out of the field of theory, into one of certain practice, what we have already said with reference

to Mr. Paget's report is obvious : that the arguments to convince of the utility of this system are of themselves almost superfluous ; it is the constant reiteration of them which is necessary.

It would, however, be hardly fair to Mr. Burt, of the eminent Millbank firm, did we omit to mention, in passing, his objections to road rolling. That gentleman does not consider "that there is any economy or saving of material in the use of a horse roller on our hard London roads," while the steam roller crushes the material over which it passes, and if rollers be employed they should assimilate closely in their action to that of the passing vehicles, which have for the most part to achieve the road rolling of the metropolis. It is hard to conceive that such an opinion, coming, as it does, from an experienced witness, can be an unprejudiced one. It is the action of the wheels of vehicles in the slow process of working down the surface that pulverizes the broken granite until, according to Mr. Burt's own statement, nearly a third of the granite is ground up into dust, to the perpetual annoyance of the public. The amount of material thus wasted is enormous ; the amount of power required to pulverize so much hard stone is enormous, and of course means so much extra wear and tear of horses, and yet it is argued that such is the best way of consolidating and surfacing a road. On the other hand, the action of the road roller is as we have described it, and when once the road is placed in order by it there is no further possibility of any pulverization except on the top exposed surface, there being no loose stones ; the attrition of each against the others on all sides is done away with.

But while it is almost impossible to exaggerate, and absolutely impossible to deny the advantages gained by the public traffic on steam-rolled roads over those that are left untouched, it may be urged by local governments that the extra cost of this process and the first cost of the engine are too great to justify its adoption. On this point we may again quote some of Mr. Paget's statistics, somewhat imperfect, it is true, but still sufficient. Thus Mr. Heaton, the Birmingham engineer, estimates a saving of £5,700 in the case of steam rollers, the present cost of maintenance being £13,000.

Mr. Newlands, of Liverpool, whilst hesitating to give exact figures, is certain of the great saving obtained. Mr. Holmes, borough engineer of Sheffield, estimates the economy at 40 per cent. The surveyor of Maidstone finds that 20 per cent. of saving is the result of using a steam roller. In like manner those parish surveyors in London who have adopted this system are unanimous in their opinion. Mr. Howell, of the St. James's district, finds a saving of $\frac{2}{3}$ of the material. The parish engineer of St. George's places the economy of material at $\frac{1}{3}$, and so on. And it should not be forgotten that, widely as the results assumed to be obtained differ from one another, the discrepancy is fully accounted for by the varying nature and extent of the traffic in different localities. But whatever may be the actual amount of material saved, it is certain that in unrolled roads, the large percentage that is lost can be only in the form of dust, ground by painful efforts from the granite fragments, and scattered broadcast by every wind. The great economy which experience points out can be effected by the use of the roller, is obviously more than sufficient to counterbalance the cost of the extra labor put upon the roads, and although it follows as a matter of course that a somewhat larger amount of metalling must be laid down at first, on account of the close packing the stones undergo in the process of compression, this increase must not be laid against the steam roller's account. On the contrary, the durability of the road, its freedom from repairs, and the smoothness of its surface, increase far more in proportion than the extra amount of metalling required.

It being proved, therefore, that rolled roads possess great advantages over those unrolled, that they are smoother, more lasting, more free from dust, requiring less repairs, the comparison between the relative merits of steam and horse rollers may be questioned, and considering that the Board of Works, while they show an anxiety to promote the use of the former, yet still continue to employ the latter, it may be imagined that some motive of convenience or economy must guide their choice in this matter. Independently of cost, the use of horse rollers is attended with many inconveniences. The pressure laid upon the road is, for the most part,

insufficient, involving a longer process of reducing the surface, and, as a consequence, a prolonged interference with the public traffic. The number of horses required for the operation produces a like inconvenience, and the manipulation of the machine has the same effect. With the steam roller it is different; it occupies less room, it works more rapidly, and does its work more effectually. It is handled more readily, and leaves the road upon which it operates sooner free for traffic. One old objection still rules against the system, it is true, namely, that it may frighten horses, with possibly serious results. But the fact is that it does not frighten horses, and such animals as would "shy" at a steam roller would find ample excuses on every highway for similar evolutions. This difficulty, which has been made so much of, is indeed one of the great retarding causes of the more free introduction of steam on common roads. Experience teaches differently. But few horses become restive even in passing beneath a railway bridge, when a train thunders overhead, making the earth vibrate, and every fibre of the iron structure ring. So in America horses do not become frightened, though they run alongside locomotives and trains as they pass through the street.

The last question, that of comparative cost between the use of horse and steam rollers, may be briefly summed up. In Bordeaux, the comparative outlay per ton per mile is as 14d. to 7d., just one-half in favor of steam rollers. In Paris, the figures per sq. metre are 0.151 francs, against 0.108 francs. In London the cost is half as much; in Calcutta it is about the same; while in America, the experience of Mr. Green, the Chief Commissioner of the Central Park, who recently purchased one of Aveling & Porter's rollers, is as follows: "That with one day's rolling with it, at a cost of $10, as much work could be accomplished as in two days with a 7-ton roller, drawn by 8 horses, at a cost of $20 per day. Hence, the work done by the steam roller was twice as much, and the cost only one-quarter that of the 8-horse roller." In this case the element of time is taken into consideration, giving a result of fourfold in favor of steam rolling. In the other statements, the cost alone is estimated, which, if taken in conjunction with the time saved, would produce practically the same results.

We have given so much space to the consideration of this subject, because we are impressed with its importance. We have freely used Mr. Paget's statistics and data, because they have been carefully collected and well put together, and we trust that his efforts towards reform in the matter of street construction and maintenance may result in the success which alone will give to the metropolis such roads as we should possess.

The Mahoning, O., "Courier," says: "This week has seen the shortest-lived miners' strike on record in this valley. The delegates' meeting, representing most if not all of the banks, which met at Hubbard on Monday, decided to strike against a reduction of 10 cents per ton. The proprietors yielded to the point, and, after being out of the mine only one day, the men went peaceably to work again on Wednesday morning. The upward tendency of coal, arising out of European troubles is the cause of so easy and speedy a settlement.

The "Press" says that science has discovered almost as many uses for the common potato as there are chemical components in it. A foreign exchange describes a new mode of preparing wood-pulp for paper-making, which consists in using potatoes in lieu of alkaline solution usually employed to effect from poplar and other white-wood fibres the removal of gummy matter.

It is certainly a curious chemical fact that the substances required to form common table salt are both of them poisonous—chlorine and sodium. No one can use either of these articles separately with safety, and yet, combine them together and they form a substance necessary to health, and one found upon every table.

All the locomotive works in Paterson, N. J., are busy at work; there is little prospect of a slackening up.

COUNTERBRACING, AS A MEANS OF INCREASING THE RIGIDITY OF A BRIDGE TRUSS.

By E. SHERMAN GOULD, C. E.

In demonstrating the offices of the counterbrace in a straight truss, most authors base their calculations on the assumption that the web has no other duty to perform than to resist the shearing strain of the bridge and load.

In this sense, it is quite plain that counterbracing in *all* the panels is unnecessary, for those nearest the abutments of a long-span bridge can never be called upon to resist compression. This is evident without calculation, from the fact that the shearing strain is thrown *right* and *left* only from the *lowest point* of a deflecting truss. Now, the action of the weight of the bridge itself is to depress the structure in the *centre*, where the braces abut, and if an additional weight be applied somewhere between the centre and an abutment, that weight can only be transmitted *right* and *left*, on condition that its point of application be the lowest point of the curve which the bridge assumes. Hence, before the counter which abuts against the loaded brace can be compressed, the applied weight must be sufficient to raise the depressed centre of the bridge, or, in general terms, to change the curve of deflection due to the weight of the bridge itself.

It is evident, besides, that the more rigid the bridge, the earlier will the counterbracing be called upon. If the bridge were perfectly rigid and incompressible in all its parts, the counterbracing would be subject to be called upon in all the panels under an applied load.

But mere resistance to shearing is *not* the only function which the web has to perform. Rigidity is as indispensable to a permanent structure as strength, and this quality can only be obtained in a long-span truss by the proper arrangement of the members of the web.

When a train passes over a bridge, the bridge deflects more or less under the weight, and when the train has passed, it springs back *beyond* its previous static position, which it regains only after a series of vertical vibrations. These vibrations it is the aim of the bridge-builder to check—first, by reducing as far as possible the deflection, and, then, the upward spring. How is this double result to be accomplished? To answer this question it is necessary to investigate the manner in which the various members of the web-ties, braces and counters, react on each other.

Suppose we should construct a small model of an ordinary Howe truss, a few feet long, and some 4 to 6 in. deep, with square panels. If all the pieces were cut according to measurement, the model would come exactly together when put up. If, however, the braces be cut a little longer than 1.414 times the ties, they will have to be forced in, the effect of which will be to cumber up the truss in the middle, and compress the ties and counters. The whole system can thus be brought well into bearing. If now a weight be applied at the centre, or evenly distributed, the truss will sink a little and loosen the counterbraces. By inserting longer counters, or wedging up those already in, the truss will not spring back when the weight is removed, and will be as rigid as its form of construction admits of. Every member will be kept in bearing, and provision will thus be made to meet every change of form the truss may tend to assume.

All this which obtains in the case of a small model, holds good, more or less, in an actual bridge; and this I conceive to be the main office of the counterbrace, viz., to resist the back spring of the truss when relieved from the rolling load. A few experiments with the model, apart from all mathematical investigation, will show that, practically, counterbraces are very little needed anywhere in a truss to resist the direct shear of the load. In proportion, however, as they increase the rigidity of the truss, they bring themselves into play to resist the shear of the rolling load.

If the above view of the counterbraces be admitted, it will be seen that to insure good service from a bridge, it should be kept in adjustment, so that all its members may be constantly under strain, in order to avoid settling under a passing load.

In closing, I may add, in reference to the most economical form of truss, that

that would seem the best which, with a given amount of material, permits the widest separation of the flanges. Mere depth is an element of strength, entirely independent of the quantity of material used, and one which the bridge-builder should, therefore, endeavor by all means to obtain. The limit to the depth of any truss is the limit of the resistance of the compressive members of the web to lateral deflection ; and attention should, therefore, be directed to such a disposition of these members as to secure for them the greatest length with the least deflection.

WHAT IS ENERGY?

By BALFOUR STEWART.

From "Nature."

It is only of late years that the laws of motion have been fully comprehended. No doubt it has been known since the time of Newton that there can be no action without reaction ; or, in other words, if we define momentum to be the product of the mass of a moving body into its velocity of motion, then whenever this is generated in one direction an equal amount is simultaneously generated in the opposite direction, and whenever it is destroyed in one direction, an equal amount is simultaneously destroyed in the opposite direction. Thus the recoil of a gun is the appropriate reaction to the forward motion of the bullet, and the ascent of a rocket to the downrush of heated gas from its orifice ; and in other cases where the action of the principle is not so apparent, its truth has notwithstanding been universally admitted.

It has, for instance, been perfectly well understood for the last 200 years that if a rock be detached from the top of a precipice 144 ft. high it will reach the earth with the velocity of 96 ft. in a second, while the earth will in return move up to meet it, if not with the same velocity yet with the same momentum. But inasmuch as the mass of earth is very great compared with that of the rock, so the velocity of the former must be very small compared with that of the latter, in order that the momentum or product of mass into velocity may be the same for both. In fact, in this case, the velocity of the earth is quite insensible and may be disregarded.

The old conception of the laws of motion was thus sufficient to represent what takes place when the rock is in the act of traversing the air to meet the earth ; but, on the other hand, the true physical concomitants of the crash which takes place when the two bodies have come together were entirely ignored. They met, their momentum was cancelled — that was enough for the old hypothesis.

So, when a hammer descends upon an anvil, it was considered enough to believe that the blow was stopped by the anvil ; or when a break was applied to a carriage-wheel it was enough to imagine that the momentum of the carriage was stopped by friction. We shall presently allude to the names of those distinguished men who have come prominently forward as the champions of a juster conception of things, but in the meantime let us consider some of those influences which served to prepare men's minds for the reception of a truer hypothesis.

We live in a world of work, of work from which we cannot possibly escape ; and those of us who do not require to work in order to eat, must yet in some sense perform work in order to live. Gradually, and by very slow steps, the true nature of work came to be understood. It was seen, for instance, that it involved a much less expenditure of energy for a man to carry a pound weight along a level road than to carry it an equal distance up to the top of a mountain.

It is not improbable that considerations of this kind may have led the way to a numerical estimate of work.

Thus, if we raise a pound weight 1 ft. high against the force of gravity, we may call it one unit of work; in which case 2 lbs. raised 1 ft. high or 1 lb. raised 2 ft. high would represent 2 units, and so on. We have therefore only to multiply the number of pounds by the vertical height in feet to which they are raised, and the product will represent the work done against gravity. The force of gravity be-

ing very nearly constant at the earth's surface, and always in action, is a very convenient force for this purpose; but any other force, such as that of a spring, would do equally well to measure work by. Generalizing, we may say, *the space moved over against a force multiplied into the intensity of that force will represent the quantity of work done.* So much for the definition of work, and it is necessary to know what *work* is before proceeding to define *Energy.*

Now what does the word Energy really mean? In the first place it does not mean force.

Two substances may have an intense mutual attraction, in virtue of which they form a very intimate union with one another; but when once this union is consummated, although the force continues to exist, the combination is singularly deficient in Energy. Nor does Energy mean motion, for although we cannot have motion without Energy, yet we may have Energy without motion.

By the word Energy is meant the power of doing work; and the energy which a laboring man possesses means, in the strictly physical sense, the number of units of work which he is capable of accomplishing.

This is a subject which at this stage we may attempt to illustrate by reference to a very different department of knowledge.

The analogy which we shall venture to institute is between the social and the physical world, in the hope that those who are more familiar with the former than with the latter may be led to perceive clearly what is meant by the word Energy in a strictly physical sense. Energy in the social world is well understood. When a man pursues his course, undaunted by opposition and unappalled by obstacles, he is said to be a very energetic man.

By his energy is meant the power which he possesses of overcoming obstacles; and the amount of this energy is measured (in the loose way in which we measure such things) by the amount of obstacles which he can overcome—the amount of work which he can do. Such a man may in truth be regarded as a social cannonball. By means of his energy of character he will scatter the ranks of his opponents and demolish their ramparts. Nevertheless, a man of this kind will sometimes be defeated by an opponent who does not possess a tithe of his personal energy. Now, why is this? A reply to this question will, if we do not mistake, exhibit in a striking manner the likeness that exists between the social and the physical world. The reason is, that, although his opponent may be deficient in personal energy, yet he may possess more than an equivalent in the high position which he occupies, and it is simply this position that enables him to combat successfully with a man of much greater personal energy than himself. If two men throw stones at one another, one of whom stands at the top of a house and the other at the bottom, the man at the top of the house has evidently the advantage.

So, in like manner, if two men of equal personal energy contend together, the one who has the highest social position has the best chance of succeeding. For this high position means energy under another form. It means that at some remote period a vast amount of personal energy was expended in raising the family into this high position. The founder of the family had, doubtless, greater energy than most of his fellows, and spent it in raising himself and his family into a position of advantage. The personal element may have long since disappeared from the family, but not before it had been transmuted into something else, in virtue of which the present representative is able to accomplish a great deal owing solely to the high position which he has acquired through the efforts of another. We thus see that in the social world we have what may justly be termed two kinds of energy, namely:—

1. Actual or personal energy.
2. Energy derived from position.

Let us now again turn to the physical world. In this as in the social world it is difficult to ascend. The force of gravity may be compared to that force which keeps a man down in the world. If a stone be shot upwards with great velocity, it may be said to have in it a great deal of actual energy, because it has the power of doing useful work, or of overcoming up to a great height the obstacle interposed by gravity to its ascent, just as a man of great energy has the power of overcoming obstacles. But this stone as it continues to mount upwards will do so with a gradually decreasing velocity, until at the sum-

mit of its flight all the actual energy with which it started will have been spent in raising it against the force of gravity to this elevated position. It is now moving with no velocity—just, in fact, beginning to turn—and we may suppose it to be caught and lodged upon the top of a house. Here, then, it remains at rest, without the slightest tendency to motion of any kind, and we are led to ask what has become of the energy with which it began its flight? Has this energy disappeared from the universe without leaving behind it any equivalent? Is it lost for ever, and utterly wasted?

To answer this we must learn to regard energy, not as a *quality*, but rather as a *thing*.

The chemist has always taught us to regard quantity or mass of matter as unchangeable, so that amid the many bewildering transformations of form and quality which take place in the chemical world, we can always consult our balance with a certainty that *it* will not play us false. But now the physical philosopher steps in and tells us that energy is quite as unchangeable as mass, and that the conservation of both is equally complete. There is, however, this difference between the two things—the same particle of matter will always retain the same mass, but it will not always retain the same energy. As a whole, energy is invariable, but it is always shifting about from particle to particle, and it is hence more difficult to grasp the conception of an invariability of energy than of an invariability of mass. For instance, the mass of our luminary always remains the same, but its energy is always getting less.

And now to return to our question—What has become of the energy of the stone? Has this disappeared? Far from it; the energy with which the stone began its flight has no more disappeared from the universe of energy, than the coal, when we have burned it in our fire, disappears from the universe of matter. But this has taken place—the energy has changed its form and become spent, or has disappeared as energy of actual motion, in gaining for the stone a position of advantage with regard to the force of gravity.

If we study this particular instance more minutely, we shall see that during the upward flight of the stone its energy of actual motion becomes gradually changed into energy of position, while the reverse will take place during its downward flight, if we now suppose it dislodged from the top of the house. In this latter case, the energy of position with which it begins its downward flight is gradually reconverted into energy of actual motion, until at last, when the stone reaches the ground, it has the same amount of velocity, and, therefore, of actual energy, which it had at first.

Let us now revert for a moment to the definition of energy, which means the power of doing work, and we shall see at once how we may gauge, numerically, the quantity of energy which the stone possesses; and in order to simplify matters, let us suppose that this stone weighs exactly 1 lb. If, therefore, it has velocity enough to carry it up 1 ft., it may be said to have energy enough to do one unit of work, inasmuch as we have defined 1 lb. raised 1 ft. high to be one unit of work; and in like manner if it has velocity sufficient to carry it 16 ft. high, it may be said to have an energy equivalent to 16 units of work or foot-pounds, as those units are sometimes called. Now, if the stone be discharged upwards with an initial velocity of 32 ft. per second, it will rise to 16 ft. high, and it has therefore an energy represented by 16. But if its initial velocity be 64 ft. per second, it will rise 64 ft. high before it turns, and will therefore have energy represented by 64. Hence we see that by doubling the velocity the energy is quadrupled, and we might show that by tripling the velocity the energy is increased 9 times. This is expressed in general terms by saying that the energy or quantity of work which a moving body can accomplish varies as the square of its velocity. This fact is well known to artillerymen, for a ball with a double velocity will penetrate much more than twice as far into an obstacle opposing its progress.

Let us now take the stone or pound weight, having an initial velocity of 64 ft. per second, and consider the state of things at the precise moment when it is 48 ft. high. It will at that moment have an actual velocity of 32 ft. per second, which, as we have seen, will represent 16 units of work. But it started from the ground with 64 units of work in it. What, therefore, has become of the difference—

or 48 units ? Evidently it has disappeared as actual energy ; but the stone, being 48 ft. high, has an energy of position represented by 48 units ; so that at this precise moment of its flight its actual energy (16) *plus* its energy of position (48), are together equal to the whole energy with which it started (64).

Here, then, we have no annihilation of energy, but merely the transformation of it from actual energy into that implied by position ; nor have we any creation of energy when the stone is on its downward flight, but merely the retransformation of the energy of position into the original form of actual energy.

We shall presently discuss what becomes of this actual energy after the stone has struck the ground ; but, in the meantime, we would repeat our remark, how intimate is the analogy between the physical and the social world. In both cases we have actual energy and energy of position, the only difference being that in the social world it is impossible to measure energy with exactness, while in the mechanical world we can gauge it with the utmost precision.

Proteus-like, this element energy is always changing its form ; and hence arises the extreme difficulty of the subject ; for we cannot easily retain a sufficient grasp of the ever-changing element to argue experimentally regarding it. All the varieties of physical energy may, however, be embraced under the two heads already mentioned, namely, energy of actual motion and of position. We have chosen the force of gravity, acting upon a stone shot up into the air, as our example; but there are other forces besides gravity. Thus, a watch newly wound up is in a condition of visible advantage with respect to the force of the main-spring ; and as it continues to go it gradually loses this energy of position, converting it into energy of motion. A cross-bow bent is likewise in a position of advantage with respect to the spring of the bow ; and when its bolt is discharged, this energy of position is converted into that of motion. Thus again, a meteor, a railway train, a mountain torrent, the wind, all represent energy of actual visible motion ; while a head of water may be classed along with a stone at the top of a house as representing energy of position. The list which represents visible energy of motion and of position might be extended indefinitely; but we must remember that there are also invisible molecular motions, which do not the less exist because they are invisible.

One of the best known of these molecular energies is *radiant light and heat*—a species which can traverse space with the enormous velocity of 186,000 miles a second.

Although itself eminently silent and gentle in its action, it is nevertheless the parent of most of the work which is done in the world, as we shall presently see when we proceed to another division of our subject. In the meantime, we may state that radiant light and heat are supposed to consist of a certain undulatory motion traversing an ethereal medium which pervades all space.

Now, when this radiant energy falls upon a substance, part of it is absorbed, and in the process of absorption is converted into *ordinary heat.* The undulatory motion which had previously traversed the thin ether of space has now become linked with gross palpable matter, and manifests itself in a motion which it produces in the particles of this matter. The violence of this rotatory or vortex-like motion will thus form a measure of the heat which the matter contains.

Another species of molecular energy consists of *electricity in motion.* When an electric current is moving along a wire, we have therein the progress of a power moving like light with enormous velocity, and, like light, silent in its operation. Silent, we say, if it meets with no resistance, but exceedingly formidable if it be opposed ; for the awe-inspiring flash is not so much the electricity itself as the visible punishment which it has inflicted on the air for daring to impede its progress. Had there been a set of stout wires between the thunder-cloud and the earth, the fluid would have passed into the ground without disturbance.

The molecular energies which we have now described may be imagined to represent motion of some sort not perceived by the outward eye, but present nevertheless to the eye of the understanding ; they may therefore be compared to the energy of a body in visible motion, or actual energy, as we have termed it.

But we have also molecular energies which are more analogous to the energy of position of a stone at the top of a cliff.

For instance, two bodies near one another may be endowed with a species of energy of position due to *opposite electrical states*, in which case they have a tendency to rush together, just as a stone at the top of a cliff has a tendency to rush to the earth. If the two bodies be allowed to rush together, this energy of position will be converted into that of visible motion, just as when the stone is allowed to drop from the cliff, its energy of position is converted into that of visible motion.

There is, finally, a species of molecular energy caused by *chemical separation*. When we carry a stone to the top of a cliff, we violently separate two bodies that attract one another, and these two bodies are the earth and the stone. In like manner, when we decompose carbonic acid gas into its constituents, we violently separate two bodies that attract one another, and these are carbon and oxygen. When, therefore, we have obtained in a separate state two bodies, the atoms of which are prepared to rush together and combine with one another, we have at the same time obtained a kind of energy of molecular position analogous on the small scale to the energy of a stone resting upon the top of a house, or on the edge of a cliff, on the large or cosmical scale.

THE CONSERVATION OF ENERGY.

It is well-known that certain organisms of the animal world do not confine themselves to one state of being or to one order of existence, and the most familiar instance of this roving habit of life is the caterpillar, which passes first into the chrysalis state, and after that into the butterfly. This habit is not, however, peculiar to the organic world, for energy delights in similar transmutations, and we have just seen how the eminently silent and invisible electrical current may occasionally be transmuted into the vivid, instantaneous, awe-inspiring flash of lightning. Nor is this element of change confined to our peculiar corner of the universe, but it extends itself to remote starry systems, in some of which there is a total extinction of luminosity for a while, to be succeeded by a most brilliant luminous outburst, presenting all the appearance of a world on fire.

We shall not enter here into great detail regarding the various changes of energy from one form into another; suffice it to say, that amid all these changes of form, and sometimes of quality, the element of *quantity* remains the same. Those of our readers who are mathematicians know what is meant by variable quantities; for instance, in the equation $x + y + z = A$, if x, y, & z are variable and A constant, you may change x into y and into z, and y into x and into z, and in fact perform any changes you choose upon the left hand side of your equation, *provided that* you keep their sum always constant and equal to A. It is precisely thus in the world of energy; and the invariability of the sum of all the energies af the universe forms the doctrine known as the "conservation of energy." This doctrine is nothing else than an intelligent and scientific denial of the chimera of perpetual motion.

Recognizing the great importance of work, it was natural enough at an early stage of our knowledge that enthusiasts should endeavor to create energy or the power of doing work, that is to say, endeavor to construct a machine that should go on working for ever without needing to be supplied with fuel in any way, and accordingly inventors became possessed with the idea that some elaborate system of machinery would, no doubt, give us this grand desideratum, and men of science have been continually annoyed with these projects, until in a moment of inspiration they conceived the doctrine of the conservation of energy!

It flows from this doctrine that a machine is merely an instrument which is supplied with energy in one form, and which converts it into another and more convenient form according to the law of the machine.

We shall now proceed to trace the progress of energy through some of its most important transformations. To begin with that one to which we have already alluded, what becomes of the energy of a falling body after it strikes the earth? This question may be varied in a great number of ways. We may ask, for instance, what becomes of the energy of a railway train after it is stopped? What becomes of the energy of a hammer after it has struck the anvil? of a cannon ball after it has struck the target? and so on.

In all these varieties we see that either percussion or friction is at work; thus it is friction that stops a railway train, and

it is percussion that stops the motion of a falling stone or of a falling hammer, so that our question is in reality, what becomes of the energy of visible motion when it has been stopped by percussion or friction?

Rumford and Davy were the pioneers in replying to this important question. Rumford found that in the process of boring cannon the heat generated was sometimes so great as to boil water, and he supposed that work was changed into heat in the process of boring. Davy again melted two pieces of ice by causing them to rub against each other, and he likewise concluded that the work spent on this process had been converted into heat.

We see now why by hammering a coin on an anvil we can heat it very greatly, or why on a dark night the sparks are seen to fly out from the break-wheel which stops the motion of the railway train, or why by rubbing a metal button violently backwards and forwards against a piece of wood we can render it so hot as to scorch our hand, for in all these cases it is the energy of visible motion which is being converted into heat.

But although this was known nearly a century ago, it was reserved for Joule, an English philosopher of the present day, to point out the numerical relation subsisting between that species of energy which we call visible motion and that which we call heat.

The result of his numerous and laborious experiments was, that if 1 lb. of water be dropped from a height of 772 ft. under the influence of gravity, and if the velocity which it attains be suddenly stopped and converted into heat, this heat will be sufficient to raise the whole mass 1 deg. Fahr. in temperature.

From this he concluded that when 1 lb. of water is heated 1 deg. Fahr. in temperature, an amount of molecular energy enters into the water which is equivalent to 772 foot-pounds, that is to say, to 1 lb. raised 772 ft. high against the influence of gravity, or allowed to fall 772 ft. under the same influence.

He found again that if 1 lb. of water were to fall twice this distance, or 1,544 ft. under gravity, the velocity if stopped would raise its temperature 2 deg. Fahr., and in fact that the rise of temperature under such circumstances is proportional to the height from which the 1 lb. of water is supposed to fall. By this means an exact relation is established between heat and work. Grove was the first to point out the probability of a connection between the various species of molecular energy; and the researches of Joule, Thomson and others, have established these relations with numerical accuracy. No better example of the correlation of the various kinds of energy can be given than what takes place in a galvanic battery. Let us suppose that zinc is the metal used. Here the source of energy is the burning or chemical combination of the zinc with oxygen, etc., in order to form a salt of zinc. The source of energy is in fact much the same as when coal is burned; it is the energy produced by chemical combination. Now, as we have said, the zinc combines with the oxygen, and sulphate of zinc is produced, but the result of this combination does not at first exhibit itself in the form of heat, but rather in that of an electric current. No doubt a great portion of the energy of this electric current is ultimately spent in heat, but we may, if we choose, spend part in promoting chemical decomposition; for instance, we may decompose water. In this case part of the energy of the battery, derived as has been stated from the burning of the zinc, is spent in heat and part in decomposing the water, and hence we shall have less heat than if there were no water to decompose. But if when we have decomposed the water, we mix together the two gases, hydrogen and oxygen, which are the results of this decomposition, and explode them, we shall recover the precise deficiency of heat. Without the decomposition, let us say that the burning in the battery of a certain weight of zinc gives us heat equal to 100, but with the decomposition only 80; 20 units of energy have therefore become spent in the decomposition, but if we explode the mixture of gases procured from the decomposition we shall get back heat equal to 20, and thus make the whole result of the burning of the zinc 100 units of energy as before.

In like manner, if our electric battery is made to do work, thus forming a kind of engine, we shall have the heat produced by the current diminished by the exact equivalent of the mechanical effect which we have obtained from this engine.

There is nothing for nothing in the universe of energy.

At this point we can imagine some champion of perpetual motion coming forward and proposing conditions of truce. "I acknowledge," he will say, "that perpetual motion, as you have defined it, is quite impossible, for no machine can *create* energy, but yet I do not see from your own stand-point that a machine might not be constructed that would produce work for ever. You tell me, and I believe you, that heat is a species of molecular motion, and hence that the walls of the room in which we now sit are full of a kind of invisible energy, all the particles being in rapid motion. Now, may we not suppose a machine to exist which converts this molecular motion into ordinary work, drawing first of all the heat from the walls, then from the adjacent air; cooling down, in fact, the surrounding universe, and transforming the energy of heat so abstracted into good substantial work? There is no doubt work can be converted into heat—as, for instance, by the blow of a hammer on an anvil—why, therefore, cannot this heat be converted back again into work?"

We reply by quoting the laws discovered by Carnot, Clausius, Thomson, and Rankine, who have all from different points of view been led to the same conclusion, which, alas! is fatal to all hopes of perpetual motion. We may, they tell us, with the greatest ease convert mechanical work into heat, but we cannot by any means convert all the energy of heat back again into mechanical work. In the steam-engine we do what can be done in this way; but it is a very small proportion of the whole energy of the heat that is there converted into work, for a large portion is dissipated, and will continue to be dissipated, however perfect our engine may become. Let the greatest care be taken in the construction and working of a steam-engine, yet shall we not succeed in converting $\frac{1}{4}$ of the whole energy of the heat of the coals into mechanical effect.

In fact, the process by which work can be converted into heat is not a completely reversible process, and Sir W. Thomson has worked out the consequences of this fact in his beautiful theory of the dissipation of energy.

As far as human convenience is concerned, the different kinds of energy do not stand on the same footing, for we can make great use of a head of water, or of the wind, or of mechanical motion of any kind, but we can make no use whatever of the energy represented by equally diffused heat. If one body is hotter than another, as the boiler of a steam-engine is hotter than its condenser, then we can make use of this difference of temperature to convert some of the heat into work, but if substances are equally hot, even although their particles contain an enormous amount of molecular energy, they will not yield us a single foot-pound of work.

Energy is thus of different *qualities*, mechanical energy being the best, and universal heat the worst; in fact, this latter description of energy may be likened to the dreary waste heap of the universe, in which the effete forms of energy are suffered to accumulate; and, alas! this desolate waste heap is always continuing to increase. But before attempting to discuss the probable effect of this process of deterioration upon the present system of things, let us look around us and endeavor to estimate the various sources of energy that have been placed at our disposal.

To begin with our own frames, we all of us possess a certain amount of energy in our systems, a certain capacity for doing work. By an effort of his muscles the blacksmith imparts a formidable velocity to the massive hammer which he wields; now what is consumed in order to produce this? We reply, the tissues of his body are consumed. If he continues working for a long time he will wear out these tissues and nature will call for food and rest; for the former, in order to procure the materials out of which new and energetic tissues may be constructed; for the latter, in order to furnish time and leisure for repairing the waste. Ultimately, therefore, the energy of the man is derived from the food which he eats, and if he works much, that is to say, spends a great deal of energy, he will require to eat more than if he hardly works at all. Hence it is well understood that the diet of a man sentenced to imprisonment with hard labor must be more generous than that of one who is merely imprisoned, and that the allowance of food to a soldier in the time of war must be greater than in time of peace.

In fact, food is to the animal what fuel

is to the engine ; only an animal is a much more economical producer of work than an engine. Rumford justly observed that we shall get more work out of a ton of hay if we give it as food to a horse than if we burn it as fuel in an engine. It is in truth the combustion of our food that furnishes our frames with energy, and there is no food capable of nourishing our bodies which, if well dried, is not also capable of being burned in the fire. Having thus traced the energy of our frames to the food which we eat, we next ask whence does this food derive its energy? If we are vegetarians we need not trouble ourselves to go further back, but if we have eaten animal food and have transferred part of the energy of an ox or of a sheep into our own systems, we ask, whence has the ox or the sheep derived its energy, and answer, undoubtedly from the food which it consumes, this food being a vegetable. Ultimately, then, we are led to look to the vegetable kingdom as the source of that great energy which our frames possess in common with those of the inferior animals, and we have now only to go back one more step and ask whence vegetables derive the energy which they possess?

In answering this question, let us endeavor to ascertain what really takes place in the leaves of vegetables. A leaf is, in fact, a laboratory in which the active agent is the sun's rays. A certain species of the solar ray enters this laboratory, and immediately commences to decompose carbonic acid into its constituents oxygen and carbon, allowing the oxygen to escape into the air while the carbon is, in some shape, worked up and assimilated. First of all, then, in this wonderful laboratory of Nature, we have a quantity of carbonic acid drawn in from the air ; this is the raw material. Next, we have the source of energy, the active agent ; this is light. Thirdly, we have the useful product ; that is, the assimilated carbon. Fourthly, we have the product dismissed into the air, and that is oxygen.

We thus perceive that the action which takes place in a leaf is the very reverse of that which takes place in an ordinary fire. In a fire, we burn carbon, and make it unite with oxygen in order to form carbonic acid, and in so doing we change the energy of position derived from the separation of two substances having so great an attraction for each other as oxygen and carbon, into the energy of heat. In a leaf, on the other hand, these two strongly attractive substances are forced asunder, the powerful agent which accomplishes this being the sun's rays, so that it is the energy of these rays which is transformed into the potential energy or energy of position represented by the chemical separation of this oxygen and carbon. The carbon, or rather the woody fibre into which the carbon enters, is thus a source of potential energy, and when made to combine again with oxygen, either by direct combustion or otherwise, it will in the process give out a deal of energy. When we burn wood in our fires we convert this energy into heat, and when we eat vegetables we assimilate this energy into our systems, where it ultimately produces both heat and work. We are thus enabled to trace the energy of the sun's rays through every step of this most wonderful process ; first of all building up vegetable food, in the next place feeding the ox or sheep, and lastly through the shape of the very prosaic but essential joint of beef or mutton entering into and sustaining these frames of ours.

We are not, however, quite done yet with vegetable fibre, for that part of it which does not enter into our frames may, notwithstanding, serve as fuel for our engines, and by this means be converted into useful work. And has not Nature, as if anticipating the wants of our age, provided an almost limitless store of such fuel in the vast deposits of coal by means of which so large a portion of the useful work of the world is done? In geological ages this coal was the fibre of a species of plant, and it has been stored up as if for the benefit of generations like the present.

But there are other products of the sun's rays besides food and fuel. The miller who makes use of water-power or of wind-power to grind his corn, the navigator who spreads his sail to catch the breeze, are indebted to our luminary equally with the man who eats meat or who drives an engine. For it is owing to the sun's rays that water is carried up into the atmosphere to be again precipitated so as to form what is called a head of water, and it is also owing to the sun's heat that winds agitate the air. With the trivial exception of tidal energy, all

the work done in the world is due to the sun, so that we must look to our luminary as the great source of all our energy.

Intimately linked as we are to the sun, it is natural to ask the question, Will the sun last forever, or will he also die out? There is no apparent reason why the sun should form an exception to the fate of all fires, the only difference being one of size and time. It is larger and hotter, and will last longer than the lamp of an hour, but it is nevertheless a lamp. The principle of degradation would appear to hold throughout, and if we regard not mere matter but useful energy, we are driven to contemplate the death of the universe. Who would live for ever even if he had the elixir of life? or, who would purchase, if he might, the dreary privilege to preside at the end of all things—to be "twins in death" with the sun, and to fill up in his own experience the melancholy dream of the poet:

> The sun's eye had a sickly glare,
> The stars with age were wan,
> The skeletons of nature were
> Around that lonely man.
> Some died in war, the iron brands
> Lay rusting in their bony hands;
> In peace and famine some.
> Earth's cities had no sound nor tread,
> And ships lay drifting with their dead
> To shores where all were dumb.

CIVIL ENGINEERING AT THE TIME OF CHRIST.

From "The Railway Journal and Mining Register."

The Roman genius for construction was the grandest the world has seen. The traveller visits the cathedral fanes of York and Bourges, Burgos and Seville, Cologne and Milan, the castles of Windsor and Heidelberg and S. Elmo, the temples at Pæstum, at Athens, at Baalbec, and at Thebes, the palaces of the Maharajahs, on the banks of the Ganges, sees monuments of splendid beauty, unsurpassed in any age, by any people; yet he returns to Rome, and says, while standing upon the vaulted ruins of the baths of Caracalla or while counting his steps across the floors of Constantine's Basilica, or while looking down from the utmost tier of seats into the arena of the Coliseum, that the constructive genius of all the rest of the world must bend before the Imperial Latin Engineer.

Never but once were thus combined in the political situation of a city all elements needful for carrying up the culture of mere building talent to the highest pitch, while at the same time were offered unlimited opportunities for its exercise. Rome was a seaport, backed by a country fertile in supplies, a peninsula of mountains made of marble, in the centre of a vast sea, crowded with well-settled islands, and girt about with coasts inhabited by the oldest and most advanced communities of man. The Roman States were still physically undebauched; in the prime of its strength; irresistible lord of all the Western and half the Eastern world; was infinitely rich; irresponsible and unscrupulous; proud and vain; sensual and sensational; loving war only for the sake of its fruits, and preferring peace for the sake of its enjoyments. The Bath-house was the church of Rome, combining the essential qualities of the Exchange, the Club, the Museum, the Bar-room, and the Polls. The Emperors enriched themselves and confirmed their power by watering their political stock. Caracalla could afford his horse a golden manger in a temple of its own, after affording his fellow-citizens a Bagnio as large as the Tuileries, in which 10,000 bathers could enjoy themselves at once, the ceilings of which were 80 ft. high, the partition walls as massive as the abutments of a bridge. The sweating-room alone was larger than the Catholic Cathedral in Philadelphia, and surrounded by arcades, inside, of costly Corinthian columns, the abstraction of which by the mediæval princes of modern Rome for use in the construction of their private palaces brought down the ceiling with a crash which shook the city as far off as the Castle of S. Angelo.

S. Peter's is built on the model of these ancient monuments. Its nave is precisely of the size and shape of the great room in the Baths of Diocletian, and of the name of Constantine's great church. Its dome is precisely the size and shape of the Pantheon, which, as is now well-known, was yet another Imperial Bath-room, since then appropriated to the uses of religion

—merely a change from hot to holy water. The great Bath-room of Diocletian is also one of the grandest churches of modern Rome. The necessity for supplying an amphibious population with floods of fluid developed the civil engineering talents of the Empire. Scores of aqueducts were constructed above ground to bring the waters of the Appenines into the city, and an elaborate system of sewerage carried it away again to be re-purified in the bosom of the Ligurian sea. While Signor de Rossi has been excavating the ancient catacombs outside the walls, and the Government antiquarian, Baron Visconti, the ancient marble yards and police stations inside the walls, and the Emperor Napoleon the foundation rooms of the Palace of the Cæsars, the British Archæological Society of Rome has been digging along the foundations of the ancient walls themselves, and opening up the underground water-works, reservoirs, and sewers of ancient days. They have determined the true site of the fountain of Egeria and of King Numa's Palace; how Royal Rome, Republican Rome, Imperial Rome were in succession fortified with longer and larger circumvallations; and how the water pipes of the engineers of the Middle Ages were ranged within and upon the conduits of Servius Tullius and the Tarquins. Any civil engineer who is curious in such matters, or would like to see nice pictures of the rubble work of his predecessors in the profession twenty-two centuries ago, can gratify himself by looking over Mr. Parker's "Notices of Recent Excavations in Rome," just published in Part I. of the forty-second volume of the "Archæologia." By the by, Mr. Parker's little hand-books of architecture are not only indispensable for the tourist, but ought to be in every American gentleman's library. And it is worth knowing, also, that the Archæological Society, which the foreigners in Rome keep up, has upwards of a thousand special photographs of specimens of Roman construction, arranged in the order of time.

The first part of this interesting collection is already for sale, and illustrates the historical construction of walls in a series of sixty-four samples, beginning with the wall of Romulus, 750 B. C., and taking on the average one for each generation. The series is continued down to the 13th century A. D. In the time of the Empire the dated examples are so numerous that they are necessarily subdivided; afterwards the churches and monasteries supply us with a continuation of the series. This is really a great work for the history of architecture, such as has never been done before. Even D'Agincourt, in his admirable work, overlooks construction, which is the foundation of all. It is sometimes impossible to get photographs from nature from want of sufficient space, and it is generally necessary to fill up the excavations again immediately, so that plans and drawings are the only mode of showing what has been made out; but photographs are made of these and sent to the Oxford Architectural Society.

THE FAIRLIE ENGINE.

From "The Railway News."

Mr. Robert Fairlie certainly deserves success, and we have pleasure in believing that he is commanding it. On Thursday last and yesterday in the little "cabbage garden" at Hatcham another of his great triumphs was exhibited in the trial of the "Tarapaca," a double bogie locomotive of 60 tons weight, coaled and watered, destined for Peru. The experiments were witnessed by some hundreds of eminent official and scientific men, who were all in accord, in so far as we could hear, in their admiration of the new engine, which for hours in succession performed the feat, smoothly and with perfect success, of turning round the oval in the gardens, the end curves being of only 50 ft. radius. The railway world has heard of Mr. Fairlie's "Little Wonder" at work upon the Festiniog Railway, and of the triumphs of the "Progress" on the Brecon and Merthy Railway. The "Tarapaca" may properly be designated the "Great Wonder," in the adaptation of steam power to locomotive purposes. As stated, the engine is 60 tons weight in working order, or 40 tons weight when empty; the bunker room is sufficient for 30 cwt. of fuel, and the tank accomodation is for 2,200 gals. of water, which should suffice for a 60 miles run.

The weight is equally distributed upon 12 wheels, in 2 groups of 6 each. The wheels in each group are coupled together, so that all the twelve are driving wheels, and the whole of the 60 tons is thus made available for adhesion. The "Tarapaca" will have to work a gradient of 1 in 26 for 11 miles on the Iquiqui line in Peru, belonging to MM. Montero Frères. The engine has 4 cylinders of 15 in. diameter and 20 in. stroke. The wheels are 3 ft. 6 in. in diameter, and the break arrangement, very powerful, is applied to the 4 inner wheels of the 12. The force of the engine at the rails is about 21,400 lbs., or $9\frac{1}{2}$ tons, and equal to hauling a load of 2,000 tons, on the level, at a speed of 12 miles an hour.

The "Little Wonder" runs upon a gauge of 1 ft. $11\frac{1}{2}$ in.; the "Tarapaca" is made for the ordinary 4 ft. $8\frac{1}{2}$ in. gauge. The Fairlie engine can double the capabilities of any line, irrespective of gauge, its power being double that of engines of the ordinary type. The Festiniog gauge is unduly narrow, and the ordinary 4 ft. $8\frac{1}{2}$ in gauge is wider than is necessary to realize the maximum advantages of the Fairlie system, which may be secured with a gauge of from 3 ft. to 3 ft. 6 in. A 3 ft. gauge line worked upon this system may be made to carry as many passengers and as many tons of goods as the broadest gauge line in existence, and it can be worked in the ordinary manner, at a speed of from 40 to 45 miles an hour. The dead weight on narrow gauge lines is much less proportionately than on broad gauge lines. A wagon for a 3 ft. gauge, weighing 1 ton, will carry 3 tons of paying weight. The best form of wagon on a 4 ft. $8\frac{1}{2}$ in. gauge weighs from 3 to $5\frac{1}{2}$ tons, and carries from 5 to 10 tons, or about 1.90 ton per ton of wagon. The average load carried by merchandise wagons, exclusive of coal, is about 10 cwt. paying weight. The load these wagons ought to carry should be from 5 to 7 tons; of paying load they really carry but a twelfth of what they ought to do. If our goods and mineral wagons were only a ton in weight, as they ought to be, they would carry 3 tons of load, or 6 times the average load now taken, and would reduce the dead weight from 4 to 1. A railway company that we forbear from naming, carries over its line 126,000,000 tons per annum, out of which it takes payment for only 15,000,000 tons of paying load. Fairlie's narrow gauge and 1 ton wagon system would reduce this gross tonnage one-half, thus saving the company the cost of hauling 60,000,000 tons per annum of dead weight. The experts who attended the trials at Hatcham on the last two days were agreed as to the entire absence of oscillation in the movements of the engine. The ordinary locomotive, it is well known, increases its oscillation, as it increases its speed, and *ipso facto* increases the power and effect of the blows inflicted upon the rails. The oscillations of the engines are communicated to the trains they draw, and danger is thus increased. The Fairlie engine, it has been fully demonstrated, runs more smoothly and faster without the pounding of the rails caused by the engines of the ordinary type.

From all that we have seen of Mr. Fairlie's Big and Little Wonders in his double bogie engines for any gauge, but preferably for a gauge of say 3 ft., we cannot doubt that the adoption of his inventions would revolutionize railway working and make the difference, as regards railway property, that there is between wasted money and lucrative investments. Ere long, notwithstanding the *vis inertiæ* of the directorial mind, we have little doubt that we will have English companies sharing with Russian, Peruvian, and Welsh mine-masters, in the benefits that Mr. Fairlie and his double bogie system are ready to confer upon them.

An engine on the Fairlie principle has recently been completed in the United States, adapted to the roads of that country. It is thus described by the "Springfield Republican:"—"The memory of that mythical divinity, the two-faced god, Janus, is perpetuated in a double-headed locomotive, built by Mason, of Taunton, after a style invented by Robert Fairlie, of England. This ponderous and unique machine, which is to become the property of the Boston and Albany Railroad, drew hither from Worcester the other day 40 freight cars, half of which were loaded. It would have drawn more had not the pump given out —a defect easily remedied and by no means vital. It will speedily be repaired, and the machine sent on a trial trip up the hills to Pittsfield immediately. This dual engine has 1 boiler with 2 heads, and at each end rests on 6 drive wheels. The

cab rests on the boiler, over the centre, where 1 lever lets on the steam. The water tanks and bunkers for coal are above the boilers on each side of the cab. In going in one direction one-half of the locomotive is going ahead and the other backing, and the latter goes ahead when the steam is reversed, and the other half backs.

"Thus the necessity of turn-tables is avoided, and it is claimed that the same amount of steam in such an engine will accomplish more than in one of the ordinary kinds."

THE INDIAN BUDGET.

From "The Engineer."

From the Budget statement of the Indian Finance Minister, on 1st April last, we learn particulars regarding the expenditure actually incurred upon public works in India during the past year, as well as the contemplated expenditure for the ensuing 12 months. It is, however, from the speech of his Excellency the Viceroy, who, as member of the Council of India, has special charge of the Public Works Department, that we derive most interesting information on the subject. Since the Indian Public Works Department is for the most part recruited by engineers from England, the amount to be annually expended upon works in India is of great moment to members of the profession in this country.

The total estimated expenditure on public works in England and India in 1869–70 has amounted in round numbers to about £8,000,000, divided into ordinary expenditure £5,300,000, and extraordinary £2,600,000. Of the sum devoted to ordinary expenditure £5,000,000, as nearly as possible, have been spent upon public works, the residue being spent upon railways and loss by exchange. The extraordinary expenditure was made up of £2,000,000 spent on irrigation works, and a small sum on State railways. The principal items of ordinary expenditure were as follows:—Military works, nearly £1,500,000, divided into original works £1,200,000, and repairs £297,000; agricultural works, £478,000, divided into £192,000 for original works, and £279,000 for repairs; civil buildings, £680,000, of which £562,000 were for original works, and £122,000 for repairs; communications, including the construction and repair of ordinary roads, £1,000,000, of which £600,000 has been spent upon original works, and £400,000 on repairs; miscellaneous and public improvements, £58,000; establishment, £1,000,000, and £70,000 for tools and plant. Of the million and a half spent upon extraordinary works, £950,000 went for irrigation, £144,000 for State railways, and £360,000 for the Bombay Special Fund. The expenditure for the current year is placed at £7,475,000, of which £6,900,000 will be expended in India, and £500,000 in England. The ordinary expenditure is fixed at £4,300,000, of which £3,900,000 will be spent upon public works; and the extraordinary expenditure at £3,100,000. Under the head of military works, the total sum to be spent in 1870–71 is £913,000 on original works, and £214,000 on repairs. The bulk of the sum assigned for "accommodation of troops" will be spent on barracks for Europeans and the improvement of unhealthy stations. Other branches of expenditure will be ordnance factories, gas works, water supply, and defences. The most important defences will be Bombay Harbor and Rangoon Pagoda. Under the head of civil works, one of the principal grants, £26,500, will be made to the Kurrachee Harbor; but the Government is inquiring whether these works could not be completed by a local trust. The grant for the Godavery navigation works is fixed at £30,500; that for the road from Dharwar to Carwar, at £15,000; Bombay Harbor improvements, at £147,500, which will be debited against the proposed port trust; Madras jails, £9,768; and the Calcutta High Court, a final grant of £40,000. The Imperial Museum and Calcutta University are set aside for the present. The ordinary grant for agricultural works for the past year was £478,279, of which £192,199 were for new works, £279,580 for repairs, and £6,500 for State outlay on guaranteed works. The extraordinary grant was originally £1,650,000, but the expenditure

is not likely to exceed £900,000. For 1870–71, ordinary works are set down at £497,300, and extraordinary works £1,-732,500, making a grand total allotment for irrigation works of £2,229,800, of which £1,415,820 will be for actual construction of new works, and £322,500 for repairs. The greater part of the ordinary grant will be devoted to repairs, from the necessity of maintaining in good working order the extensive system of irrigation works already in operation. The allotment for the irrigation works in the Godavery and Kistua Deltas is £52,760. In Bombay £545,494 has been sanctioned for extraordinary agricultural works, of which £305,898 will be spent upon a reservoir and canal at Poona. A canal from Roree, on the Indus, to Hyderabad, will probably be commenced during the year. In Bengal, works in Orissa, on the Soane, and the Gunduk are in operation; in the North-West, additions to the Ganges Canal, a canal from the Jumna, near Delhi, to Agra, and a system of similar canals in Rohilcund, and a scheme for irrigating Eastern Rohilcund, by a canal from the Ganges at a cost of £1,000, 000, is before Government. In the Punjab, the Baree Doab Canal is in progress, and the Kussoor and Sobraon branches have been recommended for construction, at an estimated cost of £270,000. The Sirhind Canal has also been commenced on an estimate of £2,250,000. The year 1870–71 will be a notable year in the railway history of India. On the 31st December, 1869, there were open in India 4,264 miles of railway, and it is expected that 5,061 miles will be open on the 31st December, 1870, or at all events before the close of the current financial year, so that it is hoped an addition will be made during the year to the railway system of India of 801 miles. Of this the Great Indian Peninsula Railway has recently opened 238½ miles of the north-east extension, and 158½ miles of the southern will shortly be opened. The north-west extension of the Madras Railway will open 94¼ miles, and the Bellary branch of the same line 32 miles; Khamgaon Railway, 7½ miles; Oomrawuttee, 5 miles; and Delhi, 32½ miles. The East India Railway will open its Chord line of 123½ miles, and the same company the Kurhurbaree branch of 24½ miles. The Eastern Bengal Railway will open the Goalundo extension of 45 miles, and the Oude and Rohilcund Railway the line to Byrom Ghat, 40 miles, making altogether a total of 801 miles, which is the greatest number of miles ever opened in India in any one single year. Sir Salar Jung has already made financial arrangements to construct a branch line from Goolburga to Hyderabad entirely at the expense of the Hyderabad State; the Maharajah of Holkar has also agreed to lend the Government, at 4½ per cent., a million of money to construct a line which will meet the Great Indian Peninsula system somewhere near Khundwa.

Peter Myers, of Cherry Hill, Indiana county, recently found a vein of iron ore on his farm, which he has followed to the depth of 12 feet, and has not yet found the bottom. It is pronounced a good quality of ore, and will doubtless prove a valuable discovery, should the quantity hold out.

J. L. Booth, of Rochester, N. Y., has invented a new rail which consists of a compound formed by first rolling the cap and base separately and then applying them together and passing them together through a rolling or compressing machine, whereby they are firmly united and without being heated for the purpose.

By means of its magnificent diversified industry, mainly of iron, in its different departments, the farmer of Berks county, Pennsylvania, has at all times a market within the borders of his own county for all his produce, and the demand is actually in excess of the supply.

A silver mine of unparalleled richness has been discovered in Greyson county, Kentucky. The ore was found to contain a larger per cent. of silver than any hitherto discovered. The mines are almost inexhaustible, and will soon be developed.

Corry manufactures 1,800 pails, and 750 tubs per day.

THE EVAPORATING CAPACITY OF BOILERS HEATED BY WASTE HEAT FROM PUDDLING FURNACES.

By J. H. RADINGER.*

From "The American Railway Times."

Boilers exposed to the waste heat of puddling or boiling furnaces, evaporate much more water in proportion to the heated surface, than those heated by common means. To gain a positive basis for the necessary capacity of the feeding-pumps to the boilers of the new additions to the rolling-mills of Count Henkel von Donnersmark, near Vienna, I lately made, on invitation of the manager, observations on the amounts of evaporated water in older boilers with the above heating arrangement, for which purpose I proceeded as follows: The three boilers on which observations were to be made simultaneously, are arranged behind three re-heating furnaces standing side by side, in a straight line, between the slag-hole and the chimney. The masonry reaches in front up to a height equal to the horizontal diameter, and the boiler is inclined towards its back part 4 in., while the line of the flue-bottom below remains horizontal. The circular front surface of the boilers is covered by a wall, in order to prevent the flame touching the joints and rivets of the plates. These three boilers, each of which is 22 ft. (6.95 metres) long and $3\frac{1}{2}$ ft. (1.1 metres) in diameter, and which consequently possess a combined heating surface of 400 sq. ft. (40 sq. metres), were all fed by one pump from a cast-iron reservoir, 30 in. in depth, the vertical walls of which surround a surface of water of 9.35 cubic ft. An inserted rule indicated the falling of the level during each feeding operation, and as, according to a simple calculation, 1 in. lowering of the level is equal to a volume of 0.77 cubic ft., the determination of the consumed quantity of water was easy and accurate.

To establish, at the same time, the useful effect of the feeding-pump (in order to enable the managers in the future to make such a measurement approximately, but in a much simpler manner), an apparatus recording the rotations was affixed to the shaft of the fly-wheel. And as the plunger has a diameter of 2 in. $5\frac{1}{2}$ lines (65 m. m.), a stroke of 8 in. $1\frac{1}{2}$ lines (215 m. m.) and every 100 strokes of the plunger are equivalent to a theoretical space of $2\frac{1}{2}$ cubic ft.; 80 to 85 strokes were made per minute, which is equivalent to 2 ft. (0.63 metres) velocity of plunger; the height of suction was in the mean $3\frac{1}{2}$ ft. (1.1 metre).

To ascertain, furthermore, the relations between the coal burnt and the water evaporated, for the purpose of comparison with other kinds of coal, we concluded to try the experiment until the known contents of a coal wagon (170 zoll-centner, or 8,500 kilogrammes) should be consumed by the three boilers. But our intentions, as far as the last-mentioned condition is concerned, had to be given up for two reasons: First, the feeding pump proved a little too weak, as it could not keep up a proper supply of water, because it had to be stopped every time during the refilling of the reservoir (the influx being continuous at ordinary times). On account of this circumstance, the three boilers contained, after $6\frac{1}{4}$ hours, 26 cubic ft. less water than at the commencement of the experiment—a fact which could be established with sufficient accuracy by the water-gauges and accurate drawings of the boilers. In the second place, the experiment was necessarily limited by an accident, the breaking of a screw in the eccentric of the rolling machine, during the repairing of which the fires under the boilers had to be smothered. The remaining coal was weighed, and found to be 30 zoll-centner; the weight of the coal burnt (from Domboan, Upper Silesia) was consequently 140 zoll-centner (7,000 kilogrammes).

With the burning of this coal and the determination of the water level, we commenced experiment No. 5 at 9.33 A. M. The first four observations were for the training of the workmen and the control of the apparatus. In experiment No. 1, for instance, a comparison of the water really introduced with the volume traversed by the plunger, showed the relation of 43:100, and by this discrepancy our attention was drawn to a small, almost

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invisible crack in an elbow of the suction-pipe, which permitted the entrance of air, and had therefore to be stopped. The indications of the hand attached to the rotation-counter must, of course, only be noticed from the time the pump catches water. If there is air in the suction-pipe, which is always the case after a stoppage for some time, the rising of the water inside can easily be followed with a hammer, a rap on the portion of the pipe containing water sounding entirely different from one on the part containing only air. And when the hand is held to the valve-box, after the water has filled the whole suction-pipe, the stroke, during which the valve falls the first time on its seat surrounded by water, can be distinctly recognized. This was always the first stroke counted.

I must also premise that the observations were intentionally made in the middle of the week (Wednesday, Sept. 15, 1869), when the masonry was at an average temperature ; that the weather was clear, and the direction of the weak currents of wind was from the grate-bars to the chimney—a fact which facilitates considerably the draft and the maintenance of an even pressure of steam. The experiment lasted from 8.24 A. M. to 3.48 P. M., and as two shifts work through the week, there can be no doubt that the conditions under which we experimented remained the same throughout. For these reasons, I am of opinion that the experiments lasted a sufficient length of time.

In the following abstract, from the record of experiments, the notes of secondary importance are omitted, and also the indications of the rule, manometer, etc. The temperature of the feed-water was nearly constantly at 10 deg. C., and the steam pressure oscillated between 3.5 and 4 atmospheres. The experiment proper lasted, without any interruption whatever of the observations (Nos. 5 to 24, inclusive), 6 hours and 30 minutes. 7,000 kilogrammes of coal were burned, the waste heat of which evaporated 11,800 kilogrammes of water, corresponding to 1.7 times their weight.

No.	Time of feeding.		Minutes.	Lowering of surface of water in reservoir (inches).	Amount of water fed in cubic feet.	Number of strokes of pump.	Volume of space traversed by plunger (cubic feet).	Useful effect of pump.
	From	To						
*1	8h.24m.	8h.36m.	12	12.5	9.60	1010	22.30	0.43
2	8h.56m.	9h. 4m.	8	21.0	15.96	750	16.70	0.95
†5	9h.41m.	9h.50m.	9	22.0	17.10	830	18.50	0.94
10	11h.10m.	11h.20m.	10	22.0	16.72	800	17.84	0.94
15	12h.39m.	12h.49m.	10	23.5	17.86	860	19.20	0.93
20	1h.59m.	2h.11m.	12	22.0	16.72	870	19.40	0.86
‡24	3h. 9m.	3h.18m.	9	24.0	18.24	900	20.07	0.91
	Time of observation 6 hours 30 minutes.			428.5	340	16.680	37.26	0.91

The evaporating capacity of these boilers at 45 kilogrammes per hour per sq. metre, is about twice as large as that of boilers having a fire-box of their own—the latter, as is well known, evaporating only 20 to 25 kilogrammes in the same time to the same surface. Nevertheless the gases pass into the chimneys so hot that the latter have to be lined with fire-brick up to two-thirds of their height, and furthermore, the relative size of the grate to the heating surface is 1:9, while with the common boilers it varies from 1:18 to 1:36.

The 7,000 kilogrammes of coal burned evaporated, as has been said, 11,800 kilogrammes of water—1.7 times their weight. This proportion, it is true, would appear extremely unfavorable, if we did not have to take into consideration that we use here only waste heat, while the real object of the fires is the working of the reheating furnaces. The producing capacity of these furnaces is, moreover, enormously

* The suction pipe let in air, and was made air-tight.
† Commencement of water and coal notations at 9.33 A. M.
‡ End of notation of water and coal consumption at 3.48 P. M.

great in this establishment. The product of 30 rails daily per furnace is hardly reached by any other iron-works in Germany.

Amount of water fed, 340 cubic ft.

Difference between water fed and evaporated in the boilers, 26 cubic ft.

Amount of evaporated water, 366 cubic ft. (11.8 cubic metres), per 6.50 hours.

Amount of evaporated water, 56.3 cubic ft. (1.81 cubic metres), per 1 hour.

Per 1 hour and 1 sq. ft., 0.14 cubic ft. (8 lbs.).

Per 1 hour and 1 sq. metre, 45 kilos.

RECLAIMING LAND FROM THE SEA.

From "The Mechanics' Magazine."

It has been frequently asserted that the most expensive way of obtaining possession of land is by reclaiming it from the sea. There is not the slightest doubt but that in many instances this assertion has unfortunately proved indisputable. But it is by no means an inevitable sequence that this particular truth should hold good in general, or that those examples in which it has been made manifest might not have demonstrated the contrary had they been differently managed. When failure attends any engineering scheme or project through the ignorance or incompetence of those who are intrusted with the management of its constructive or financial departments, men are but too ready to visit their own faults upon the project itself. They are at once ready to condemn in future all schemes of a nature similar to that which has proved abortive under their own inefficient mal-administration, and thus endeavor to save themselves by avowing the impracticability of that which at one time they regarded as easily achievable. Obviously, they have no other course to pursue, for to believe in the feasibility and success of a project which had died a natural death under their own agency, would be to virtually confess their own inability to contend with the difficulties inseparably attendant upon all works of a somewhat hazardous character. It is perfectly true that failure, even of the most disastrous nature, has attended attempts at reclaiming land from the sea. Equally true is it that success, sometimes of a very remarkable character, has been the result of works of a similar description. Both of these statements will be accepted by our readers as recognized facts, and there is not the slightest necessity on our part to adduce instances to corroborate their accuracy. We shall endeavor in the present article to give some sound practical reasons why failure has attended many of these praiseworthy endeavors to deprive the sea and rivers of territory that they have usurped, and to give to mankind the fertile acres that should of propriety belong to them.

One of the greatest mistakes entertained respecting reclaiming land from the sea is that any land that lies between high and low water mark is fit for reclamation. Considering the great skill and science that are now brought to bear upon all engineering works, it would be perhaps going too far to assert that there is any land so situated, or even in a worse position, that could not be reclaimed. The limits of all such reclamations are bounded, not by engineering, but financial considerations. Land, after all, is only worth so much an acre, and the whole question resolves itself into a simple calculation of capital and interest. As a rule, land to be reclaimed is purchased for a mere song, so that the cost of the works necessary to reclaim it has to be set against the cost of a similar area of land elsewhere. It cannot be denied that the comparatively trifling cost at which a large tract of semi-submerged coast can be obtained is the principal inducement for the investment of capital therein. There are two essential points to be kept in view in purchasing land for intended reclamation. In the first place, the soil must either be of a fertile character or capable of becoming so by the process known as "warping." Secondly, the materials for constructing the embankment must be obtainable on the spot or in the immediate vicinity of the proposed works. There is not the slightest difficulty at arriving at correct information on these points. An analysis will supply the former, and a careful inspection and examination the latter.

Whatever may be the nature of the soil the bulk of the bank must be made with it. If clay, so much the better, if sand, so much the worse; but in any case they must constitute the chief means of embanking the land. Other materials will be also required according to the nature and extent of the work. If parts of the ground be excessively soft and spongy so as not to be able to bear the superincumbent weight of the bank, or if the material be liable to be washed away before it have time to become thoroughly incorporated and consolidated, fascines, or bushes of some kind, must be laid down so as to retain the earth *in situ* until it become firm and consistent. When a very soft piece of foundation is reached, it is idle to think of ever substantially erecting the bank by simply making up its height and slopes as they gradually sink and subside. Something must at once be done towards preventing the gradually slow but certain slipping away of the whole bank. This description of subsidence must not be confounded with that which results from mere settlement and shrinkage of the material, an allowance for which is always made in the estimate for the work. It is a common occurrence, when a portion of a bank is situated on a soft substratum, for the bank to sink, and by its weight to cause the earth to rise in the "delph" or side cutting from which the material has been excavated to form the bank. This is a very annoying circumstance, and sometimes it entails a good deal of trouble and expense before it can be arrested. Considerable discretion must be observed in the employment of bushes or other substances which are specifically lighter than water. If they are not either staked down or loaded with stone, they will be lifted up by the upward pressure of the water, and the bank will be what is termed "blown up."

In order to protect the sea or outer slope of the bank it must be covered with sods or pitched with flat stones. The latter plan can only be adopted in those situations where stone is easily and cheaply procurable. It is, however, absolutely necessary to pitch the outer slope wherever there is any great wash of sea on, as in that case the sods would not form a sufficient protection, although they answer well under ordinary circumstances. They are usually cut wherever they can be got, are about 8 in. or 9 in. deep, and are well beaten on to the slope with a wooden beater or mallet. In some cases, they are let into the slope their full depth, but this is not necessary, except near the toe of the slope. The best protection for a bank against the force or reach of the sea is a piece of foreshore, which should always be left outside it. Unfortunately, it is but too common a practice to diminish this space so much that it becomes nearly useless for the purpose of protecting the bank. Its object is to break the force and roll of the sea, so that by the time it reaches the bank its force is spent, and it scarcely does more than impinge upon the outer slope. It is particularly necessary to leave a good piece of foreshore in front of those portions of the bank which are the most exposed to the prevailing winds and currents. Under no circumstances should it be permitted to be cut away, as it constitutes a far better natural barrier than the best constructed bank can ever prove. The neglect of this precaution has resulted in the failure of a good many banks, and ruined projects that would, if properly managed, have turned out lucrative investments.

With a tolerably good foundation and suitable material, there is very little to apprehend in the construction of a sea bank. It is all pretty plain sailing, and all that is required is extreme vigilance and care on the part of those who are responsible for the construction and maintenance of the work. Constant supervision and inspection is indispensable when an enemy so treacherous as the sea is continually on the alert to destroy the banks which are erected, to restrain his violence and limit his sway. The real and serious difficulty to be overcome in embanking lands from the sea is the stopping of the numerous creeks and inlets with which many coasts abound. Such of these as are of insignificant dimensions are stopped by simply increasing the size of the ordinary bank, but those which assume large proportions demand special treatment. In many instances a regular dam has to be formed, which consumes a large amount of timber, which should be of large scantling. It is a great mistake to be chary of the piling in these situations. If the piles are too slight and not sufficiently braced together, they will be

snapped off short by the force of the water, and the earth washed away in one tide. It is a good plan, when there is danger of the slopes slipping where the bank crosses a creek, to pile the toe, or to construct the dam, with a couple of extra rows of piling, placed somewhere about the level of low-water mark. In any case the use of stone will be found of great service in preventing slipping, provided the foundation is not so soft as to engulph it. If the creeks be once well stopped, and the dams found to remain staunch for a few months after construction, and after being exposed to the storms of winter, the reclamation may be pronounced an engineering success. The erection being accomplished, the maintenance is all that requires to be looked after in future.

SANITARY WORKS FOR DANTZIC.

From "Engineering."

The town of Dantzic has been rendered memorable in the pages of history on account of the various sieges it has withstood in the time of warfare. It is one of the most strongly fortified positions in the kingdom of Prussia. Here the Government have extensive shipbuilding yards, and factories for the manufacture of the needle gun. The whole bed of the river Vistula flows close past the walls of the town, and forms the principal entrance for shipping from the Baltic, which is about 4 English miles, by the channel of the river, distant from the town. The place is now chiefly celebrated for its exports of corn and timber, and within the last 5 years much attention has been given to the sanitary condition of the place. In 1865, Mr. Wiebe, C. E., Government engineer of Berlin, prepared a project for the authorities of the town for effecting its sewerage. Nothing, however, was done with respect to this project, as no engineering work of like character has ever been carried out in the kingdom of Prussia, and as the engineer who advised this scheme of sewerage had had no practical experience with regard to the execution of such works. In 1868 Messrs. J. & A. Aird were consulted as to the feasibility of carrying out the plan. In 1869 they recommended that an English engineer should be called in to advise and report upon the scheme proposed by Mr. Wiebe. Mr. Baldwin Latham, C. E., of 7 Westminster Chambers, S. W., was the engineer selected, and from his report, which was presented at the time of his visit and inspection, we quote the following observations: "It has been my privilege to examine, report upon, and carry out the sanitary works in a large number of English towns, but in the whole course of my experience I have never before been called upon to visit and inspect a town in which such an utter disregard is paid to sanitary measures as I find in Dantzic; and I am still more surprised that such an unsanitary state of things could be allowed to exist for one moment longer than necessary in any civilized community. Pure air is absolutely necessary if life and health are to be maintained, and in Dantzic, where a great number of persons are congregated in a comparatively limited area, the retention of such offensive matter that everywhere meets the eye (if only retained for a limited period) is effectually vitiating the atmosphere which the inhabitants are compelled to breathe; and the result is that your death-rate is greatly above the average of any German town." The rate of mortality in Dantzic, in 1869, was 37 per 1,000, and the birth-rate was very much lower than the death-rate. Mr. Latham points out that "Dantzic must, without doubt, sooner or later, decline, unless the population is maintained by the influx of people from other parts of the Prussian Empire." The fearful death-rate of Dantzic, judged merely in a political point of view, he shows, "cannot be without its warning, as the town is unable to maintain the number of its population without drawing on the resources of the empire. The unsanitary condition is immolating its victims faster than they are being supplied in the ordinary course of nature; therefore it is not very difficult to see what must be the ultimate result of this state of things if allowed to proceed. In a financial point of view there is nothing so expensive as disease and death. The power of physical

ability forms the basis of value of all labor, and yearly Dantzic, with its frightful rate of mortality, must be called to sustain the burden arising from the physical inability of a portion of its population to sustain life by reason of the effects of disease, or the removal by death from preventable disease of the bread-earner of the family." To bring the sanitary state closer home, Mr. Latham states that "the great rate of mortality is due to the deaths of the younger portion of the population. This in itself at once testifies the necessity for sanitary reform, because it is seen that those of tender years, who live more closely in contact with the causes that are so prejudical to health and life—and who naturally, from the fact of their age, are less capable of withstanding the inroads of disease—suffer the most. The excessive mortality among the young may be taken as a sure sign of the want of proper sanitary arrangements, by which arrangements the predisposing cause of disease may be removed. It appears that the present average duration of life in Dantzic is but 23 years. This is an extremely low average, and at once speaks to you in the strongest terms as to the absolute necessity of looking at the matter in a philanthropic point of view, of doing something whereby the ride of disease and death may be staid. I have not the slightest doubt, in my own mind, that if proper sanitary measures are adopted in Dantzic the average duration of life will be increased at least one-third, and that the death-rate will be reduced in proportion." There are at the present time about 70,000 inhabitants within the fortifications, and about 20,000 in the suburbs and adjacent thereto. It is pointed out, in the report already referred to, that taking the population of the two places, and by the reduction of the rate of mortality, at least 1,200 lives may annually be saved by the prosecution of sanitary works.

Of the scheme proposed by Mr. Wiebe, Mr. Latham speaks in very high terms, but suggesting, however, such modifications as experience in similar works has found to be necessary in order to render a system of sewage efficient. Shortly after the consideration of the report referred to by the town magistrates, the works of the contract were given to Messrs. J. & A. Aird, of Berlin, to carry out the project, embracing such alterations and additions as were suggested by Mr. Latham. A concession of the sewage of the town and about 2,000 English acres of land have been granted to Messrs. Aird for a term of 30 years. It is pointed out in the report that a scheme for the utilization of sewage was absolutely requisite in a town situated like Dantzic. The Baltic being a tideless sea, the river flowing from the town of Dantzic being extremely sluggish, and much used by the shipping, and generally for mercantile purposes, the discharge of large volumes of sewage would be attended with very baneful effects ; therefore it was absolutely necessary in a town so situated that the sewage should be conveyed direct to the sea or into the river channels in as pure a state as possible. Owing to the low level at which many portions of the district lie, in order to maintain a system of sewage, it was necessary that pumping should be resorted to for the purpose of effecting the drainage of the town, so that it became a question of but slightly increasing the power of the engines in order to lift the sewage on to the lands in the neighborhood. Close to the town are many thousands of acres of sterile land of little or no value; the application of the sewage to this land, therefore, would, of itself, confer a great benefit upon the town by converting sterile wastes in its immediate vicinity into the most fertile land. The town, within the fortifications, may be considered to be divided into three portions, all of which are surrounded by water, either by the fortifications or by branches of the rivers running through the town. The central portion, having water on both sides, is entirely occupied by granaries. A small unoccupied portion in the central part, called the Kampé, which is an island of itself, is the point where the whole of the sewers in the town and suburbs are made to converge. The sewage is conveyed to the pumping station by siphons laid under the navigable channels of the district, so that for navigation 18 ft. of water have to be maintained. The principal sewers are of brick, and have a fall to the point of outfall of 1 in 2,400. Subsidiary sewers are constructed of earthenware pipes. The principle kept in mind is to lay them in perfectly straight lines, with a manhole or ventilator at each vertical or lateral change of direction.

Every manhole can be used as a flushing station. The system of sewerage has also been adapted to the efficient ventilation of the sewers. The system being so broken up, the gases will not traverse from the lowest to the highest districts, but the ventilation of each district will be secured locally. The ventilators used are "Latham's patent combined manhole ventilator and lamphole." The sewage on arriving at the pumping station is passed through two of Mr. Latham's patent sewage extractors, similar to those in use at Croydon. These extractors remove the sand and other solid matter which it is not intended to apply directly to the land. The liquid sewage is then pumped through a 22 in. main, about 2 miles in length, to the proposed area for irrigation. This area until recently has been covered with pine forests, which is being cleared as fast as possible, in order to fit the land for the reception of the sewage. From experiments that have already been made with regard to the application of sewage to land, it has been shown that crops equal to those produced in this country are capable of being grown there. The highest chemical authorities in the United Kingdom of Germany pronounce the irrigation system as being not only the best, but the only possible system whereby sewage may be properly utilized, and we trust that Messrs. Aird, who have the concession of these works, and who are taking the lead in this matter in Germany, will meet with the success of which they are in every sense deserving.

ARRANGEMENT AND MAINTENANCE OF BATTERIES.

By GEORGE B. PRESCOTT.

From "The Journal of the Telegraph."

Among the most important matters pertaining to the management of our lines, not only in a pecuniary point of view, but in their relation to the practical working of the wires, are the construction, maintenance and distribution of the batteries which supply the main circuits. The pecuniary importance of the subject is apparent from the fact that more than $100,000 are annually expended by the Western Union Telegraph Company in this department alone, the cost averaging nearly $1 per mile of wire. As there is, however, a material difference in the annual expenditure at the various stations where main batteries are maintained for supplying the same length of circuit, it shows that there is a considerable margin for improvement in many sections of the line. As all the employees should aim at securing the best results in every department, it is very important that the principles which govern the propagation of the electric current should be so well known that every one connected with the service may be able to attain the maximum of efficiency and economy in the management of his batteries. The design of this article is to furnish such information as is apparently required to secure a uniform system of batteries throughout the Western Union line.

The cost of maintenance of a galvanic battery is proportional to the amount of zinc and acids consumed.

The consumption of zinc and acid in a properly constructed battery of any given number of cells, is proportional to the number of wires (of equal resistances) supplied from it, or to the amount of work done.

The consumption of zinc and acids in working a given number of wires of a certain length, size and quality, is proportional to the number of cells in the battery.

The quantity of electricity required to operate a telegraph wire is an amount sufficient to work the relays in the circuit.

The quantity of electricity which exists in the form of a current upon a given length, size and quality of wire, is proportional to the number of cells in the battery; for, while the quantity of electricity produced by a battery is proportional to the amount of zinc decomposed in each cell, and is no greater in a battery of 100 cells than in a single element, the electro-motive force which is required to overcome the resistance of the conductors, or to force the quantity generated by the single cell through the wire, increases with every additional cell.

The quantity of electricity existing in

the form of a current upon a telegraph wire from a given number of battery cells, is inversely proportional to the resistance of the wire, relays and battery.

To summarize :

The electro-motive force being constant, the quantity of electricity which flows through any circuit is invariably proportional to the resistance.

The resistance being constant, the quantity of electricity which flows through any circuit is directly proportional to the electro-motive force.

It is evident from the above considerations that the number of cells employed in a battery for working a telegraph wire should be strictly proportional to the resistance of the wire and relays. If a battery of a certain number of cells is employed to work several wires, the resistances of all the circuits should be approximately the same ; for if a wire 100 miles long is attached to a battery which supplies another wire of twice the length, the shorter wire will have twice the quantity of current that the longer wire receives. If, therefore, the electro-motive force of the battery is sufficient to work the longer wire, it is twice as great as the shorter wire requires, and the surplus strength is wasted. In estimating the length of a wire, of course the resistances of the relays must be included, and the size and condition of the wire, or its conductivity, properly considered.

Let us suppose that a battery of 50 Grove's cells supplies a current to the following wires, and, applying the foregoing principles, ascertain what the strength of current will be upon each wire :

No.	1	Wire,	150	miles long,	with	38	relays.
"	2	"	150	"	"	34	"
"	3	"	150	"	"	29	"
"	4	"	150	"	"	24	"
"	5	"	150	"	"	18	"
"	6	"	85	"	"	14	"
"	7	"	170	"	"	7	"
"	8	"	100	"	"	13	"
"	9	"	100	"	"	5	"
"	10	"	100	"	"	3	"
"	11	"	150	"	"	2	"
"	12	"	50	"	"	2	"

Call the electro-motive force E.
" resistance of the line L.
" " " relays R.
" " " battery r.
" quantity of the current Q.

Then $Q = \frac{E}{L+R+r}$

Assuming that the electro-motive force of the battery is 50,000 units ; the resistances of the relays 200 ohms each ; the resistance of the wire 20 ohms per mile ; and the resistance of the battery 50 ohms, we have the following as the quantity of electricity, or strength of current upon the above wires. E=50,000.

No. 1	L=3000;	R=7600;	r=50.	Strength of current,	4 69
No. 2	L=3000;	R=6800;	r=50.	" "	5.07
No. 3	L=3000;	R=5800;	r=50.	" "	5.64
No. 4	L=3000;	R=4800;	r=50.	" "	6 37
No. 5	L=3000;	R=3600;	r=50.	" "	7.51
No. 6	L=1700;	R=2800;	r=50.	" "	10.9
No. 7	L=3400;	R=1400;	r=50.	" "	10.3
No. 8	L=2000;	R=2600;	r=50.	" "	10.75
No. 9	L=2000;	R=1000;	r=50.	" "	16.37
No. 10	L=2000;	R= 600;	r=50.	" "	18.87
No. 11	L=3000;	R= 400;	r=50.	" "	14.49
No. 12	L=1000;	R= 400;	r=50.	" "	38.49

Thus it will be seen that the strength of the current on No. 12 is more than 8 times as much from the same battery as upon No. 1, and the expense for material consumed is increased in the same proportion. The cost for zinc and acids for working 12 wires of the various resistances above-mentioned, from one battery, would be equal to that for supplying 22 wires of resistances similar to the greatest.

Aside from the fact that the expense of maintaining the batteries is unnecessarily increased by attaching short wires to batteries arranged for working long circuits, there arises more or less difficulty in operating the wires, owing to the variations of the current, which would be materially lessened by connecting only wires of similar resistances to the same battery.

By our system of working with closed circuits, we depend for our signals upon the difference in the strength of current at the receiving station, occasioned by the opening and closing of the circuit at the sending station. In dry weather, this difference may be nearly 100 per cent., and in wet weather, perhaps less than 5, so that during a heavy rain storm, when the escape is very great, the variations in the strength of current upon a receiving wire, occasioned by simultaneously opening and closing half a dozen keys at the receiving station, upon other wires attached to the same battery, would be greater than the percentage of difference caused by opening and closing the circuit at the sending station.

As the consumption of battery materials is proportional, other things being equal, to the number of wires operated, the cost of supplying the wires with an electric

current is theoretically the same, whether you employ one battery for working 20 wires, or a separate battery for each wire; but, practically, there would be some saving in the expense of taking care of one battery instead of 20, as well as in the loss from local action; so that if you work a number of wires of equal resistances from one Grove battery, the expense would be somewhat less than if a separate battery were employed for each wire. Much better results in working our lines, however, especially in wet weather, would be secured by using a separate battery for each wire, but as this would necessitate the occupation of considerable additional room at most large stations, which could not readily be obtained, it is scarcely practicable to inaugurate the change at once. The next best thing to having a separate battery for every wire, is to have as many batteries, in proportion to the number of wires, as can conveniently be obtained.

There is a limit to the number of wires which can be properly worked out of one battery, even in the most favorable weather, and in wet weather this limit is reached much sooner than is generally imagined.

The maximum strength of current is obtained when the resistance of the battery equals that of the closing arc. Now, as the resistance of conductors is inversely as their conducting powers, multiplying the number of conductors divides the resistance.

Suppose, for example, 30 wires of No. 8 gauge, each 230 miles in length, were attached at their termini to two Grove batteries of 50 cells each. The resistance of the two batteries would be 100 ohms, and the resistance of each wire 3,220 ohms; but as multiplying the number of wires divides their resistance, the resistance of the 30 wires would be but 107 ohms, or only 7 ohms more than that of the battery. This, it will be observed, is in dry weather, when there is no escape; but if, during a heavy rain storm, the amount of current that escapes to the ground be six times as much as that which traverses the wires, then the total resistance of the closing arc would be but 18 ohms. Thus, in rainy weather, the resistance of the wires would be so greatly reduced as practically to put the battery on short circuit, and it would run down very rapidly in consequence.

Where a great number of wires are worked from one battery, or where the wires are poorly insulated, a slight improvement is made by placing two batteries side by side and connecting the poles of the same name together. This is equivalent to doubling the size of the zincs, and reduces the resistance of the battery one half. In the case above mentioned, if the batteries had been arranged in this manner, the resistance of the batteries would have been but 50 ohms, and therefore the proportion of resistance of wire to battery would have been doubled.

This mode of arranging the batteries is sometimes erroneously called doubling the quantity. As the quantity of current generated by a battery is proportional to the amount of zinc dissolved in each cell, and this decomposition is directly proportional to the electro-motive force of the battery, and inversely by the resistance of the circuit, the quantity is only increased by enlarging the size of the zincs in proportion to the reduction of the resistance.

In a long telegraphic circuit, the increase in the strength of the current in the wire by reducing the resistance of the battery is barely appreciable, as will readily be seen by the following examples:

Take a battery of 100 Grove cells, arranged in the usual manner, and attached to a No. 8 iron wire 230 miles in length. Calling the electro-motive force 10,000 units, the resistance of the wire 3,220 ohms, and the resistance of the battery 100 ohms, the quantity of current on the wire would be $\frac{10{,}000}{3220+100}=3.01$.

Now take two batteries of 100 cells each, and place them side by side with the poles of like name connected together. The electro-motive force will be the same as in the other case, but the resistance will be halved, and therefore the strength of current on the wire will be $\frac{10{,}000}{3220+50}=3.05$.

If the 100 cells were divided into two series of 50 cells each, and these were placed side by side with the poles of similar name connected together, the electro-motive force would be reduced 50 per cent., and the resistance 75 per cent., and therefore the strength of current on the wire would be $\frac{5{,}000}{3220+25}=1.54$.

Thus, while doubling the size of the battery, by placing two series of 100 cells each side by side, only increases the quantity of electricity on the wire $\frac{4}{100}$ of 1 per cent., the division of the bat-

tery into two series of 50 cells each, arranged side by side, reduces the quantity of current on the wire 48 per cent. To obtain the same strength of current upon an ordinary telegraph wire by doubling the size of the batteries in this manner requires, therefore, twice as many cells as in the ordinary arrangement. Of course a battery of this kind would last twice as long—when supplying an equal number of conductors—as one of the ordinary construction ; but as it costs twice as much to make it, and double the fluid to feed it, there is no economy in its use.

If the proposition were : What arrangement of the cells will best supply the largest number of wires from one battery with the least difficulty? the answer would be, the latter ; since, as with the electromotive force the resistance is halved, the number of wires may be doubled ; but as twice as many cells are needed to produce this result, there is no economy in the arrangement, because the additional series of cells could just as well be used as another single battery, and the wires divided between the two.

As the number of cells in the battery should always be proportional to the resistance of the circuit worked, it will be found useful to have a fixed standard to refer to as a guide in arranging the batteries for the lines. From a somewhat extended examination of the battery power actually employed upon our wires in various sections of the country, I find that one Grove cell is the maximum amount required for working through 120 ohms circuit resistance. Such stations as may not have the means of accurately measuring the resistances of their wires and relays may make an approximately correct estimate in ohms by multiplying the number of relays by 200, the number of miles of No. 8 iron wire by 14, and the number of miles of No. 9 iron wire by 20. Of course, this mode of arriving at the comparative resistances of the circuits is very rough and imperfect, and is only suggested for such exceptional cases as may exist where no tests of the wires and relays have been made with a galvanometer. There ought not to be a mile of wire in operation, or a relay in use, the resistance of which is not accurately known. Of course, the conductivity of a wire is materially increased by soldering the joints, and much less battery power is required to work the same length and size of wire where the joints are soldered than where they are not. In the absence of accurate measurement, this matter should be taken into account in estimating the number of cells required to work a given length of wire.

A considerable diversity of opinion exists in regard to the comparative economy of employing the different kinds of batteries for working the main circuits. Without discussing the various theories advanced by the advocates of each particular combination, I would suggest that as the consumption of zinc and acids is proportional, in every case, to the amount of work done, there would not appear to be any substantial reason for the great differences in the cost of maintenance of one kind of battery over another, or of the different varieties of the same species of battery, which are claimed ; and the actual expenditures for this branch of the service seem, upon examination, to render this question rather one of economical use of the variety employed than of any peculiar merit in the kind selected.

The Western Union Telegraph Company employs the Grove, Carbon, and, to some extent, the Daniell batteries, to work its main circuits, the three kinds being used in the following proportions : Grove, 53 per cent.; Carbon, 43 per cent.; Daniell, 4 per cent.

A careful examination of the actual expense for battery power at each office where main batteries are located shows that the annual cost per mile of wire averages precisely the same for both Grove and Carbon, and approximately the same for the Daniell. This result is the more remarkable since the expense per mile of wire is as various as the number of stations, no two offices showing the same cost for either of the batteries. As would naturally be anticipated, the cost per mile of wire is greatest where the number of cells employed for each battery is out of proportion to the length of circuit to be worked, or where a large number of wires of greatly varying resistances are attached to the same battery. This result is so general that an examination of the expenses at any office furnishes an almost absolute index of the disposition of the batteries, or amount of force employed at that place.

Great care should be taken to keep the batteries in good order and prevent any local action in them. The floors and tables in the battery room should be kept scrupulously clean and dry, and each cell thoroughly insulated, so as to prevent the least leakage or escape of the current. Particular attention should be given to the ground wires attached to the batteries, as the strength of current upon the wires depends greatly upon the degree of conductivity of the ground connections. It is preferable to employ a separate ground wire for each battery, and they should, wherever possible, be attached to metallic water pipes, or to the main gas pipes. In all cases the joints of the wires, and the connections with gas or water pipes, should be securely soldered. Whenever it is impracticable to connect the ground wires to water or gas pipes, they should be attached to large plates of copper buried in the earth to a sufficient depth to insure their being at all times surrounded by moisture. I have frequently doubled the strength of current upon a wire by simply improving the ground connection.

Batteries which are only used during the day should be invariably taken down at night, and the nitric acid poured into glass vessels and tightly corked, so as to prevent waste from evaporation. By adding a little fresh nitric acid each morning the strength of the batteries may be constantly maintained. Much unnecessary expense is incurred by throwing away only partially used acid. The sulphuric solution employed in the outer cells should never be stronger than one part acid to twenty of water, but it is well to change this solution often, for when it becomes saturated with nitrate of zinc, the action of the battery is very much weakened. The saturation of the solution manifests itself by the formation of crystals upon the zinc cylinders.

The number of wires attached to one battery should never exceed five ; for, although a much greater number can be worked from a single series in dry weather, without appreciable inconvenience, the unavoidable difficulties due to imperfect insulation in rainy weather are unnecessarily supplemented by those arising from over-worked batteries. As no possible gain can be secured by thus overloading them, but, on the contrary, much loss is almost certain to result from this source, there can assuredly be no good reason for continuing the practice.

The result of the foregoing considerations may be briefly stated thus. To secure the best working currents at the least expense :

The batteries should always be kept in the best condition for work, each cell being thoroughly insulated, and the floors and tables in the battery room kept scrupulously clean and dry, so as to prevent the least leakage or escape of the current.

The number of cells in the batteries should be strictly proportional to the resistances of the circuits which they are to supply.

If more than one wire is supplied from the same battery, the resistances of all the wires attached to it should be approximately the same.

Five wires is the greatest number that should, under any circumstances, be supplied from one battery.

The number of cells in all the batteries employed upon one circuit, should not exceed one cell for every 120 ohms resistance.

New Colorimeter.—M. Duboscq, of France, has invented a new instrument for measuring the differences of tint in solutions. Two glass cylindrical vessels, containing the liquids to be tested, are placed side by side on a shelf ; in each is a smaller tube closed at the lower extremity by a glass dish, which may be raised or lowered by means of a pinion having fastened to it a vernier moving over a graduated scale, so as to measure the distance between the bottom of the vessel and the lower disk of the movable tube. Luminous rays are transmitted through the bottom of the cylinder, by means of a mirror and by two Fresnel rhombs above the cylinder, in such a manner that each will illuminate half of the field with a semi-disk of yellow light more or less intense. These colors are observed with a terrestrial eye-piece formed of four glasses, by which the field may be illuminated with perfect uniformity. The colors are proportional to the height of the columns if the liquid contain the same proportion of caramel, or in proportion to the richness of the liquid in caramel if the two columns have the same height.

THE CONSTRUCTION OF PIER 4 OF THE KANSAS CITY BRIDGE.*

Work was begun upon this foundation on the 2d of September, 1867. The water was then 20 ft. deep, and piles could be driven only with great difficulty; no less than 6 were pulled out by the current. It was at first designed to scour out a deep pit by the use of wing dams, but before the plan could be carried into effect, the current, which is more variable at the site of the pier than at any other point on the line of the bridge, slackened to almost nothing, making wing dams wholly impracticable. A caisson of rectangular form was then built in position, 67 ft. long, 30 ft. wide, and 22 ft. high. It was put together without spikes or pins, the planks being secured between cleets on the sides of the posts, and the whole caisson bound together by iron rods passing from the bottom of the sill to the top of the plate. It was proposed to sink this caisson about 20 ft., drive a pile foundation within it, cut off the piles at the level of the base of the caisson, build the pier on a suspended grillage, and lower it upon the piles. Then upon unscrewing the nuts and withdrawing the long rods, the caisson would fall in pieces and a riprap protection could be thrown close around the pier.

The slackening of the current was accompanied by a rapid deposit of sand, and before the caisson could be completed there remained but 18 in. of water at the site of the pier; in 8 days only, from the 18th to the 26th of September, a deposit of 12 ft. deep was formed. On the 26th of October the caisson was done, when it was tripped to the bottom by striking the braces which supported it. The change in the level of the river bed made a corresponding increase in the distance which the caisson must be sunk by excavation. This excavation was shortly begun by means of the steam siphon and hand dredge, and continued until the tools were transferred to Pier No. 3, the caisson having then been sunk about 9 ft. During the winter an inner wall was completed within it, and the intermediate space, about 5 ft. wide, was filled with stone and sand. An ice breaker, formed of an inclined sycamore log and a fender of planked piles, was built above the pier site. In February a large dredge, with a steam-engine to drive it, was mounted upon the caisson; it was set in motion on the 13th of that month, and lowered the caisson a few feet. The rising water on the 8th of March produced a moderate scour, which aided the sinking; on the 17th the scour increased very rapidly on the south side, and the caisson began to tilt over; the next morning the water was found to be 22 ft. deep there, while no corresponding wash had occurred on the north side. Under the combination of this undermining of the southern cutting edge, and the pressure of the sand against the north side, the caisson settled over till only the north-east corner remained above water. By hard work through the morning and dinner hour the machinery was removed and placed on boats. By 2 P. M. the whole caisson had disappeared; the weight of the sand and stone with which the walls were loaded, together with the external sand pressure, proved too great for so loose a structure; it broke in settling, and became a total wreck; a few of the timbers cleared themselves, and floated down stream, but the greater part of the wreck, being of green oak and covered with sand and stone, remained at the bottom of the river.

The loss of this caisson put an end to the work which had thus far been done on this foundation, making it necessary to start entirely anew. Moreover, the circumstances attending the wreck showed the exposure of this site to be so great that it was thought unwise to adhere to the plan of a pile foundation. The situation of this pier, between the edge of the sand bar and the low-water channel, exposes it to more frequent washes and deposits than have been observed elsewhere, while it is also liable to be subjected to the thrust of a heavy bank of sand on the north side, with no counterbalancing pressure on the south side, a danger from which the other piers are free. For these reasons it was determined to treat this as a channel foundation in preparing the new plan, and to extend the full-sized pier down to the

* The Kansas City Bridge. By O. CHANUTE, C. E., and GEORGE MORTON, Assistant Engineer. New York: D. Van Nostrand, 1870. For some account of the superstructure see September No. of this Magazine.

rock. To avoid the difficulties of passing through the old wreck, which would have made it necessary to resort to the use of compressed air, and which it was feared would have delared the completion of the bridge through another season, the location of the pier was shifted 50 ft. to the south, reversing the distances between it and the two adjoining piers, and placing the long span, 250 ft., between piers Nos. 4 and 5.

At the location now selected, the rock was assumed to be at an elevation of 55 ft. and to be overlaid, during the best working season, with about 40 ft. of sand, which would probably make it necessary to do some portions of the work in 50 ft. of water. Borings taken indicated rock at 58 or 59, but were not wholly satisfactory. The methods by which the other deep sand foundations had been put in, though successful, had been very slow, and were likely to prove impracticable when the depth of sand became doubled, while, even if a bottomless caisson could be sunk to the depth now required, the season between two floods would be found too short to complete the work by putting in a subaqueous foundation of beton, 30 or 40 ft. deep. For these reasons a plan was prepared resembling in many respects the process which was first introduced in founding the piers of the bridge over the Rhine at Kehl, and which has since been very generally employed by European engineers; in all previous works, however, the excavation has been made by laborers working in a pneumatic chamber—machinery, if used at all, serving only to remove the material which had first been handled by the men; but in these plans the machinery was so arranged as to be self-feeding, and the excavation was carried on without the use of compressed air. A pier of masonry was to be built in position above water, and sunk to the rock, by excavating the underlying sand with dredges working through wells left in the masonry, guiding the mass in its descent by suspension screws, and keeping the top of the masonry above the surface of the water by building on the successive courses as the sinking continued.

A caisson was designed which should serve as a support for the pier in its descent, and which, while of such form as should furnish the best facilities for excavation below, should bear, without yielding, the weight of 40 ft. of masonry above, and the pressure of sand and water against its sides. The construction of this caisson was begun on the 25th of June, 1868, on the north bank of the river, 400 yards below the bridge line. It measured 70 ft. from nose to nose, 20 ft. 6 in. in width, and 11 ft. in height. The sides were built of square timber; the main sills were of oak, 15 in. square, of one piece from shoulder to shoulder; the 7 succeeding courses were pine, 8 in. by 12, placed on edge, and the 2 upper timbers were oak, 12 in. square; a triangular piece of oak was placed below the main sill. The successive courses were pinned together with 2 in. turned pins of oak, and bolted to uprights placed in the angles, and at intermediate distances along the sides; the outside was covered with 2 courses of 3 in. oak plank, dressed in a planer to an even thickness, the planks of the inner course making an angle of 45° with the horizontal timbers, and those of the outer course being put on vertically, with the smooth side outwards. It was at first proposed to cover the whole with thin sheet-iron to reduce the friction of the sand upon the sides; but experiments made to ascertain the coefficients of friction of sand against various substances, showed so slight a difference between iron and dressed oak, that the covering was not put on. Within this outer wall was placed a second wall inclined inwards; it was framed of oak timbers, 10 in. square, which rested upon the main sills and bore against a pier of 12 in. timbers, placed parallel with the upper timbers of the sides; this inclined wall was carried round the triangular ends, the framing being modified to accommodate the angles. Three braces, 15 in. square, were placed immediately above the main sills, extending across the caisson and bearing against the upright timbers; these served also as the basis of 3 V-shaped cross-walls, each formed of 2 equally inclined rows of oak sticks 8 in. square, fitted into 15 in. timbers above; the lower angles of the cross-walls were formed by triangular pieces of oak, along the lower edges of which ran 3 iron rods, 2 in. in diameter, which passed through the main sills and tied the whole caisson together; each cross-wall was further strengthened by a truss built into the middle of it. The timbers of the inclined

walls were thoroughly stayed by iron bolts binding them to the outer walls, and the cross-walls were strengthened by rods connecting their upper timbers; the interior framing of the starlings was secured by hanging it from a truss placed above, and the top of the caisson was tied across by 2 in. rods placed at the shoulders, and by dovetailing the 15 in. cross timbers into the sides. The whole interior frame was sheathed with 2 in. oak plank, but the spaces between the double walls were left entirely open above. The cutting edges of both main and cross-walls were protected by a covering of $\frac{3}{16}$ in. boiler plate, the plates being bent and cut to fit the angles and corners, riveted together and fastened on with wrought-iron spikes.

The combination of the V-shaped cross-walls, with the inclined walls of the sides, divided the interior of the caisson into 4 bell-shaped chambers, the two central ones being nearly square, and those at the ends of pentagonal form, each having a rectangular opening above 5 ft. 4 in. by $9\frac{1}{2}$ ft.. This form is one at once well suited to sustain the weight of superposed masonry, and especially adapted to facilitate excavation. The caisson is thoroughly braced by the interior walls, and not encumbered with exposed brace timbers; the walls and edges are of such form as to act as wedges, which, under the weight of masonry, and by pressure above, feed the sand towards tbe centres of the chambers where the dredges work; while, as the cross-walls were placed 30 in. above the outer edge, a diver could have free access from chamber to chamber, should this be found necessary.

Twenty-four suspension rods, each 24 ft. long and $2\frac{1}{2}$ in. in diameter, with the upper end formed into an eye, were built into the walls. They were arranged in pairs, and passed through every square timber in the outer walls, taking hold with nut and washer on the under side of the main sills, the nut fitting into a square recess cut in the triangular stick below. Eighty $1\frac{1}{2}$ in. gas pipes were also placed in the caisson, arranged along the sides and cross-walls, and terminating in cast-iron nozzles immediately above the iron plating; they were intended for water-jet pipes, but the sand fed itself so well to the dredges that none of them except those in the angles were ever used. The whole planking was thoroughly caulked, and the interior coated with roofing pitch. A frame, provided with bolt holes, was carefully fitted into the rectangular opening above each chamber, and an accurate pattern taken, from which a cover could be made to fit this frame; so that in case extraordinary obstructions were encountered, the dredge could be withdrawn, the cover or trap placed in the frame, and bolted tight by a diver, converting the chamber into an air-tight caisson, when the obstructions could be removed by working in compressed air.

Under other circumstances it would have been preferred to build this caisson entirely of iron; but the distance from adequate iron works, and the absence of boiler-makers and competent workmen, were unfavorable to doing so; on the other hand, timber could be obtained without difficulty, and there was no scarcity of carpenters; so that it was thought best to build of wood, which involved much complicated detail and difficult framing.

The caisson was provided with a false bottom placed below the cutting edge, over which it fitted like the cover of a paper box, braced against the cross-walls, and secured by iron rods. Five launching ways were placed below, which were carried out into deep water on piles, and the completed caisson was lowered by jack-screws upon 5 flattened timbers, fitted with guides, and arranged to slide on the ways.

The first work done in the river was to drive a compact clump of anchor piles, 100 ft. above the proposed pier; these were driven and protected by riprap before the June flood; but it was thought unwise to drive the false-work piles at that time, because, even if they should remain undisturbed by scour, they would inevitably collect a large amount of drift, which might form an obstacle in the way of sinking the pier scarcely less serious than the wreck of the old caisson. On the 9th of August this danger was passed, and the driving of the false-work piles was begun. They were 60 in number, of which 48, two at each end, were intended to carry the weight taken by the suspension screws, the other 12 serving only as supports for the false-works. The two central piles on the lower end were not driven till after the caisson had been floated into place. The disturbances

of the river made the driving of these piles less exact than it should have been, but the irregularities were not too great to be taken out in the platform above; they were generally driven from 25 to 30 ft. into the sand, some of them even reaching the rock.

The piles were cut off as soon as driven at an elevation of 106.5, a platform was built upon them, and the trusses were raised which were to carry the suspension screws. These trusses were 7 in number, and proportioned to carry a safe load of 1,000 tons. Each end truss carried 2 suspension screws, and each of the intermediate trusses 4, the screws being in pairs, and placed to correspond with the rods in the caisson. These screws were 24 ft. long, ten of them 3 in. in diameter, and the other 14, which had been used in lowering the masonry of the Quincy Railroad bridge, $2\frac{1}{2}$ in. Ten additional screws of the same size as the latter were kept in reserve.

On the morning of the 21st of October the caisson was successfully launched and towed to the false-works. Two or three weeks previously a large flat-boat loaded with sand, in attempting to shoot the works, had struck against one of the upper piles and sunk; the wreck had caused a sand deposit at the pier site, so that, though there was plenty of water to float the caisson, which drew only $3\frac{1}{2}$ ft., it could not be brought under the trusses without removing the suspension rods; they were, accordingly, unscrewed, taken out, and the caisson brought into position, when they were replaced and easily screwed into the nuts, which were held by the square recesses cut in the triangular timber below the sill. This was accomplished in a day, but the want of deep water proved a more serious obstacle in the way of removing the false bottom. It had first been proposed to sink the bottom by throwing in sand, water being already admitted above it, make fast to it with the steamboat, and pull it out below; the depth of water proving insufficient for this, it had to be broken in pieces, and taken out in small parts, an operation which involved nearly two weeks' delay, and which, it was feared, would cause trouble by leaving unremoved fragments; an apprehension which fortunately proved groundless. A week later a sand bar, which had already been observed forming in front of the launching ways, had so much increased that it would have been impossible to launch the caisson, so that a tedious portage by land was narrowly escaped.

On the 11th of November, the work was begun of filling the spaces between the double walls of the caisson with beton, while the false-works were completed, and the machinery mounted as fast as could well be done. The false-works were built with 3 floors; the lower one, intended for the use of carpenters and masons, was placed at at elevation of 108.7, and made a continuous platform extending on all sides of the caisson; it was generally left open on all sides, but a small house was built at the south-east corner, in which a 25 horse-power engine and a donkey pump were placed; a room was also enclosed in the middle of the south side for the use of the divers, where the air-pump and submarine apparatus was kept. At the south-west corner a staircase led to the second floor, which was placed on a level with the lower chords of the trusses. This floor extended over the caisson, having 4 holes in it through which the dredges worked; it was completely housed in, was provided with work benches, warmed by stoves, and contained the lamp-room and superintendent's office. At either end a staircase led to the third floor, a narrow platform, resting upon the upper chords of the trusses, where stood the 4 hand-crabs used in handling the dredges.

The excavating machinery consisted of 4 large dredges of the endless chain pattern. They were mounted with vertical telescopic frames of wood, the lower tumbler being attached to a single frame, inclosed by a double frame which carried the upper tumblers; the boxes of the upper tumbler were set on adjustable blocks. By this arrangement the dredges could be lengthened to suit the depth at which they were operating, the length being varied from 51 to 85 ft.; this was done by removing the bolts which united the 2 frames, putting in an additional length of dredge chain, with the proper number of buckets, and raising the outer frame till the length of the added chain was taken up; the bolts were then replaced and such slack as might remain in the chain taken out with the adjusting screws. The entire frames were raised

and lowered independently of this change in their length, by chains which passed through sheaves on the sides of the double frame, and were worked by the crabs on the upper floor. Two of these dredges had originally been used on the Quincy bridge and were now rebuilt to adapt them to this work; a third was similar, and had been made from the same patterns, though designed in the first instance for use at Kansas City, on the old No. 4 foundation. These 3 dredges had square tumblers of cast-iron; the links of the chains measured 22 in. between centres, and the buckets were bolted on every fourth link through holes drilled for the purpose. The other dredge was constructed especially for use on this pier; the tumblers were of hexagonal form, made of oak and bound with wrought-iron; the chain links were only 12 in. long between centres formed with upset ends; the buckets, whose form was novel, were placed on every sixth link and held by the same pins by which the links were coupled, an arrangement relieving the links of any transverse strain, the merit of which was proved by the fact that the chain of this dredge never broke; the hexagonal tumbler was also found to give a steadier motion than the square ones.*

A single line of shafting mounted on hangers attached to the trusses, and driven by the engine on the floor below, extended from the east end of the house till opposite the western dredge; on this shaft were placed 4 pulleys, each arranged with clutch and lever, by which it could be thrown out of gear independently of the others, and the power was carried to the dredges by belts driven by these pulleys. The new dredge was mounted at the west end of the pier, and the dredge at the east end was also provided with buckets of the new pattern. These two dredges were worked through bevel gearing, the power being transmitted at any elevation by a pinion sliding on a vertical shaft; the other two were driven more directly by the belts, which were kept tight under all elevations by a loaded tightener sliding in a vertical frame; the latter arrangement proved the better one. Each dredge was completely boxed in between the second and third floors, to confine the splash, thus keeping the machinery and works upon the second floor dry and in good working order. The dredges discharged towards the north, the sand falling on inclined troughs which led to the lower platform, from which it was carried off in wheelbarrows, on runways built for the purpose, and deposited 100 ft. north of the works.

The machinery for handling stone was on the lower platform. It consisted of a railway and cars, the same which had been used at Pier No. 1, running along the west end of the works, and two travellers running lengthwise with the pier, between the wells and the sides of the caisson. A floating derrick was moored on the south side of the works, by which the stones were lifted from the stone barges and placed on the car; the car was then pushed under one of the travellers, the stone raised by a hand-crab which was placed at the east end of the works till it cleared the car, and drawn forward till opposite the desired point by a steam crab, which was likewise at the east end of the works, and driven by the same engine which worked the dredges, both sets of machinery rarely being worked together. This apparatus was not mounted till the beton in the two lower sections of the caisson had all been put in.

Soon after the caisson was brought into position the rectangular openings into the lower chambers had been surmounted by timber boxes; this was continued from time to time as the sinking progressed, the successive sections of these well walls being made of such a height as was found most convenient. When the hollow walls of the caisson had been filled with beton a second section was built above it; this section was an open frame structure, covered with 3-in. oak plank dressed in a planer, and similar to the caissons used at Piers 1 and 3; the long sides were given a batter of 1 in 16, but the short sides of the starlings were built plumb; additional lengths were also put on the gas pipes. This section, like the lower one, was filled with beton, about one-half the full amount being put in before starting the machinery. The beton was mixed upon the platform, thrown at once into the caisson, and beaten down with a paving maul. It set rapidly, forming a satisfactory compound; the caisson thus

* A patent for the improvement in these dredges was issued to the authors of this work, bearing date January 18, 1870.

became merely the covering of a single artificial stone or monolith, of the form most convenient for the work, and which carried the masonry of the pier above.

On the 11th of December the ice closed at the bridge line, and the river froze across. A week later the ice, which was still thin, began to rot rapidly under a strong sun, and on the 19th it broke up and went out. No serious damage was done, but a large sheet of ice, jamming above the draw rest, forced inwards the ice along the north shore, which, swinging on a pivot, about the anchor piles above the works, tore out two piles on the north-west corner of the false-works of this pier, the injury being done at one of those points where the exposure was supposed to be least. The damage was soon repaired ; one of the piles had only been bent over, and was drawn back into place ; the other, the corner pile, was destroyed, but the platform was made secure by bracing below.

On the 28th of December the machinery was started ; a few unimportant changes were found desirable, but its performance was, on the whole, very satisfactory. For the first week it was driven only by day, while the forces were being organized and drilled to their work. On Monday, the 4th of January, two gangs were put on, and the work proceeded both night and day. Each gang had a superintendent at its head, Mr. Tomlinson taking the day, and Mr. Bostwick the night shift ; a master of machinery had general charge of the 4 dredges, while two mechanics were assigned to the care of each dredge ; an engineman and fireman tended the engine on the lower floor, another man was given special charge of the donkey pump, and a spare machinist was employed upon odd jobs ; a large gang of laborers completed this force ; all the laborers worked under one foreman, and the majority of them were employed in wheeling off the sand, but 12 men were detailed to work the crabs on the top floor, and a few more to tend the suspension screws, while it occasionally became necessary to call in the entire force for the latter work. The same force was, of course, duplicated for the second shift ; each gang worked from 7 to 7 o'clock, the day gang being allowed an hour at noon for dinner, and the night gang being furnished with hot coffee at midnight.

Eight vertical rods, graduated into feet and tenths, were fastened on the sides of the caisson, one at each end and shoulder, and one in the middle of each long side ; they served as gauges to measure the descent, 8 blocks placed on the platform opposite them, at an elevation of 109, answering as reading fingers ; the gauge at the west nose was numbered 1, that on the south-west shoulder, 2, and so on continuously around the pier. The dredges were also numbered from 1 to 4—the new dredge at the west end being number 1. A full journal of the progress of the sinking was kept by the superintendent, from which a set of tables, illustrating the behavior of the pier and conditions of the sinking, were prepared. These tables, which give the best illustration of the actual working of the plan, are printed in Appendix E.; they contain a statement of: 1st. The number of hours' work performed by each dredge, with the estimated daily excavation. 2d. The readings of the gauges, daily progress, and average elevation of the cutting edge. 3d. The soundings opposite each gauge, and average elevation of the sand surrounding the pier. 4th. The displacement and the actual and effective weights of the pier. 5th. The area of the surface in contact with the sand, and the effective weight for each square foot of such surface in contact, with estimated friction.

The material dredged was at first a soft sticky silt, which could be handled only in connection with a large amount of water in the form of a thin, flowing mud. The work was conducted very carefully, the gauges were constantly watched, and the screws were tended continually ; with these precautions little difficulty was experienced in keeping the pier true ; after it had been sunk 10 or 12 feet the surrounding sand answered as a guide, and less care was required to regulate the descent. Owing to the weight of the pier and the care with which the machinery had been arranged, the sinking proceeded at a very much more rapid rate than had yet been accomplished with the bottomless caissons, and exceeded the expectations of the engineers. On the 6th of January, only two days after both shifts of men had been put on, the work had to be suspended, because the beton could not be put in fast enough to keep pace with the descent, and from this time forward the

chief difficulty lay in building up the pier rather than in sinking it. The water jets were found to be of less service than had been anticipated, the wedge-shaped edges feeding the sand to the dredges without their assistance; streams of water were occasionally passed through the pipes at the nose and shoulders, and all the outside pipes were lengthened as the height of the caisson was increased, but those in the cross-walls were allowed to be buried up in the beton.

On the 7th the machinery had to be stopped again, and it remained idle nearly a week; on the 8th the beton was nearly all in, reaching to the top of the second section. A third section had meanwhile been added, 12 ft. high, the end walls of which were at first made only one-half this height, to facilitate handling the stone. On the 9th the river rose about a foot, causing a strong current on the south side of the works, which was found to have increased the depth of water from 9 to 17 ft., so that the pier began to settle over slightly, till held by the suspension screws; 150 gunny bags were filled with sand and thrown overboard among the piles and along the side of the caisson, which suspended the scour.

On the 13th the masons began work, laying the first course of stones on the hardened surface of the beton; in the evening of the same day the dredgers were again set in motion, and the work of sinking resumed. The following day the river began to rise again, repeating the scour of the preceding week; the wash was again restrained by the use of sand bags, over 500 of which were thrown around the works on this and the two succeeding days. This method of protection was found effective, while it was free from the objections which prevented the use of riprap; if stones had been thrown around the pier it was feared that they might work under the edge of the caisson and obstruct the descent; the sand bags might also work under the edge, but their soft and yielding nature would prevent their doing harm; some of them did actually find their way inside of the caisson, and one was brought up in a dredge bucket uninjured.

It being found impossible to lay masonry as fast as the dredges could sink the caisson, the plan was adopted of running the machinery only by night, and giving the masons every convenience for work by day. Mr. Tomlinson then took charge of the night shaft, and the pier was sunk for the remaining distance under his directions. The masons were often unable to do more than set the face stones of a course, together with a few of the heavier pieces of backing, in a day, in which case the night force would be employed during the first hours of their shift in backing up with beton. The material excavated had changed to a coarse sand which was easily handled, each dredge throwing six full buckets in a minute; the pier also settled more rapidly than hitherto, sinking 5 in. in an hour when everything was working well. The lower platform and the second floor were lighted by locomotive head-lights, which threw a strong glare over the works and men, and a visit to the pier late in the evening, when the machinery was all working to its best advantage, and half an hour showed a decided settlement, became a very interesting thing.

On the 19th, a pile top was found buried in the sand below dredge No. 2, which was secured by a diver and drawn out with little trouble. The next day some timber, supposed at first to be the branches of a large snag or tree, was discovered under the lower end of the caisson. An additional diver was sent for, and after a few days' delay the log was cut through and drawn out, when it was found to be a broken pile, probably belonging to the works of the wrecked foundation. Another old pile was found near it, which extended from outside of the caisson nearly to the centre of the eastern chamber, passing under the cutting edge; a line was made fast to it and attached to a set of falls to the upper falseworks, and held in this manner while the sinking proceeded; on the 1st of February, this pile broke off under the cutting edge and was drawn up through the well hole; it proved to be a stout hickory stick, nearly a foot in diameter, and showed a rough broom-like fracture; it had been carried down with the caisson several feet before breaking, and the outside portion still remained under the edge, where it was found by a diver when the caisson had nearly reached the rock. While the divers were at work upon these sticks, it became necessary to jet away the sand around them, thus forming a cavity close

to the edge of the caisson; in two or three instances this caused sand slides, the sand suddenly caving in, filling up the cavity and raising the water in the wells; at one time the water in the wells was raised 3 ft. above the level of the river, when the soundings showed a hole 10 ft. deep outside the caisson, over the point where the slide occurred; this, however, was soon filled up by caving in and by fresh deposits.

On the 3d of February, the masonry was finished to the top of the sill of the fourth section, which had now been added, or 39 ft. above the cutting edge; as this was less than 2 ft. below the point at which the ice-breaker courses were to be started, it was thought best to lay no more masonry till a permanent bearing had been reached upon the rock. Borings recently taken had found the rock at an elevation of 56.6, though the auger had apparently been disturbed by loose stones 3 or 4 ft. before it reached that depth. In the evening of the 4th the pier settled rapidly; the machinery had never worked better, and 6 in. descent was noticed in an hour; but at midnight it came against some hard substance and almost stopped. The diver at first reported rock, but the pier went down 9 in. during the next 3 days, and though the dredges threw out a large number of loose stones, the obstruction was found to be a mass of clay under the south edge; the upper section was filled with sand, and under the pressure of this additional weight, 17 in. more descent was obtained. It was evident, however, that the bed rock was covered with about 3 ft. of loose stones mixed with a moderate quantity of stiff blue clay; the foundation would probably have been perfectly safe if kept where it was, but it was still thought best to place it directly upon the rock.

An additional number of divers were engaged, and on the 16th of February, a force of 8 divers, with 4 air-pumps and the proper complement of tenders, was ready for the work; they were divided into 2 gangs, and the work was prosecuted both night and day, one man working in each chamber. The depth of water in the wells was about 50 ft., and to render the work less burdensome, the water was warmed by sending steam down the water jet pipes. The stones were removed singly from under the edge, piled up in the centre of the walls, and placed in the dredge buckets; the dredges were worked for a short time after the divers had come up, bringing up the smaller stones; the largest rocks were left below. The stones were of all sizes, from small pebbles to boulders containing 2 or 3 cubic feet; the larger ones were mostly of limestone, and showed few or no signs of wear; the smaller pebbles were well rounded, and of diverse geological character, presenting a strange collection of the different formations found on the eastern slope of the Rocky Mountains; sandstone, granite, moss agates, and many other minerals were mixed in wild confusion, while bits of water-charred wood, reduced almost to pure coal, and several varieties of teeth, were found among them; an Indian arrow head was also picked out of the lot.

On the 10th of March the rock was reached, at the elevation of 56.6. A hole was drilled into it 5 ft., as had been done at the 3 other channel foundations, and no sign of any flaw or weakness discovered. A row of bags, filled with freshly mixed beton, was placed around the edge, as had been already done at 2 of the other foundations, and the dredges were removed and the wells filled up with beton, laid under water, with the same boxes that had previously been used at Pier No. 2. Divers were still employed, to make sure that the beton filled up the whole space of the lower chambers, packing well in towards the edges, and covering the boulders which had been left piled in the centre; the sand was thrown out from above the masonry, and the upper sections of the well walls were torn away, to secure a good bond between the masonry and the filling of beton.

The layer of boulders had been the cause of considerable delay, while it had also been productive of some additional expense; but the character of the larger stones, which, by their roughness, showed that they were seldom, if ever, disturbed by the water, indicated the perfect security of a foundation put in at this depth; and the mere presence of such material was equivalent to 3 ft. of riprap protection around the base of the pier.

The false-works were stripped, the trusses taken down, and on the 26th of March nothing remained above the lower platform. A 5th section was added to the caisson as a security against any rise in

the river ; a derrick was mounted on the platform on the north side of the pier; on the 2d day of April the laying of masonry was resumed and the pier was built up at once.

This foundation, which from its situation might fairly be regarded as much the most difficult on the work, became, in its final execution, the most successful of all, and was put down in a less time than was consumed on any other deep foundation. The plan here adopted is believed to admit of wide application ; and, while it is more expensive than the simple foundations which are used in ordinary streams, it becomes a cheap method of founding in deep and unstable bottoms. By slight modifications it can be combined with the pneumatic process, in such a way as to allow extraordinary obstacles to be removed by men, while the entire sand excavation is made by machinery. It is also applicable to foundations of extraordinary depth, where the pneumatic process must fail from the inability of the men to stand the air pressure ; it could be carried to a depth double that to which pneumatic tubes or caissons have been sunk, with the occasional use of the air chamber for a very short time; and if this be entirely dispensed with, it may even be extended to a depth of several hundred feet in clean sand, or with machinery sufficiently heavy to remove obstacles.

EXPERIMENTS UPON THE STRENGTH OF DIFFERENT SYSTEMS OF BRICK AND CEMENT FLOORS.

From "Extraits des Annales du Conservatoire" through "Revue Industrielle."

M. Garcin proposes to replace the brick work ordinarily employed between the iron beams of fire-proof floors by a system of voussoirs of plaster, forming by their union a resemblance to a course of freestone.

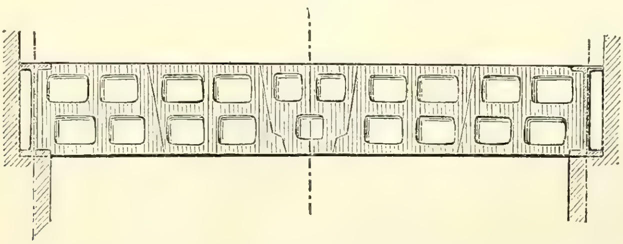
The voussoirs are pierced with regular openings to reduce their weight. Each course is formed of 5 voussoirs, with inclined sides, each having 4 tubular openings except the key-stone, which has but 3. The extreme blocks rest upon a double T beam, the hollow side of which they fit accurately. These blocks, employed with joints of plaster, form arches, which M. Garcin has submitted to tests, to compare their strength with the other systems which are employed in a similar manner.

For this purpose two double T beams were held securely by bolts parallel to each other, and 0.745 m. apart. The height of the beams was 0.12 m. Between these beams arches of several different systems or kinds of material were built, each having a span and thickness corresponding to the supports, and a length of 0.45 m.

Some days after, each was placed horizontally between two supports, and secured by wooden wedges in an embrasure in such a manner as to prevent any flexure of the iron beams.

Each was then loaded with boxes, containing iron balls, along the centre of each arch to the breadth of 0.37 m., or half the span.

Fig. 1.



The first tried was an arch of Garcin's system (Fig. 1), made in cement three weeks previously. It presented a surface of 0.745 m. $\times$ 0.45 m. = 335 sq. metres, and weighing 41.3 kilogrammes, which is equal to 123.3 kilogrammes per sq. metre.

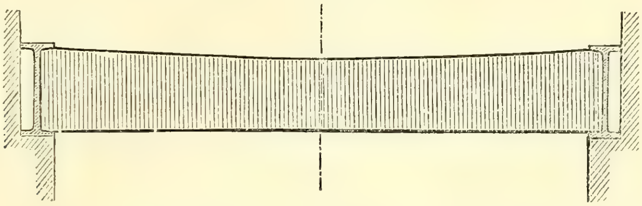
The second was of plaster, the same system and the same age as the first, and

weighing 102.4 kilogrammes to the sq. metre.

The third example was of ordinary plaster, slightly trough-shaped, so that the thickness at the middle of the span was only 0.095 m., and the weight 130.5 kilogrammes per sq. metre. (See Fig. 2.)

The fourth trial was upon a system

Fig. 2.

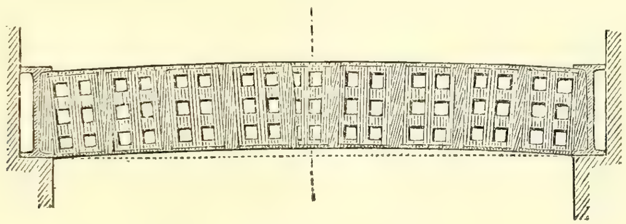


formed of hollow bricks, laid with plaster joints, without cambre, and weighing 128.7 kilogrammes per sq. metre.

The fifth was formed of bricks, of the same kind as the last, forming an arch, with a versed sine of 0.010 m., obtained by the aid of inclined joints, with a wedge-shaped key-stone; weight, per sq. metre, 143.6 kilogrammes. (See Fig. 3.)

These two latter specimens had each 9

Fig. 3.



bricks in the span, the bricks weighing 1,960 kilogrammes to the 1,000, and laying (edgewise) 55 to the sq. metre.

The test load in each case has been carefully increased up to the point of rupture.

The following table exhibits the result of these experiments :—

No.	Systems experimented upon.	Breaking weight in kilogrammes.	Breaking weight per metre. kilogrammes.	Weight of masonry per sq. metre. kilogrammes.
1	Garcin's System in Cement	736	2340	123.3
2	" " Plaster	880	2790	102.4
3	Ordinary " Plaster	592	1880	130.5
4	" " Brick, without arching	1448	4720	128.7 } 136.2
5	" " " slightly arched	1824	5790	143.2 } 136.2

The third and fourth columns show the comparative advantages of the different systems.

The voussoirs of M. Garcin weigh 102.4 kilogrammes per sq. metre, but their ultimate resistance is only 2,790 kilogrammes.

The systems in brick work weigh 136 kilogrammes, but they resist up to 5,790 kilogrammes weight. These figures show for each of these systems their relative security, and afford suggestions as to the method of judiciously employing each.

The "Post" thus sums up the manufacturing interests of Detroit : Capital invested, $10,000,000 ; value of annual productions, $21,000,000 ; amount of wages to laborers and mechanics, $5,000,000 ; number of employees, 9,000.

A blast furnace is soon to be erected near Zanesville, Ohio, which, when completed, will give employment to 150 men.

THE FOSBERRY MITRAILLEUR.

From "Engineering."

Were we desirous of writing the history of the progress of invention as affecting munitions of war, we should turn neither to the records of the Patent Office for the last 20 years, nor to contemporaneous history for the same period, for materials, although both teem with matter pertinent to the subject. But that very matter is, for the most part, such a tangled mass, and the line of demarcation is in many instances so very faintly drawn between the rights of one inventor and those of his neighbor, that the task of assigning to each his just due would be simply impossible. Besides, a compiler of history must deal with facts and not fancies, and for every one of the former he would find a score of the latter in the sources to which we have above referred, and he would there find nothing to assist him in discriminating between the one and the other. Now, a fact is a reality, a thing done, an aim accomplished, an idea brought into tangible shape, and, above all, into practical use. Hence, if we would note the actual and absolute progress made in our war *materiel*, we must take our stand upon the battle-fields of modern times, for we shall find each one to constitute a new era in the art of war. Each will be found to be marked by the practical introduction of one new agent of destruction or another, the development of which, however, is generally due to times of peace. Thus the French campaign in Italy saw the remarkable results to be attained by rifled guns; the American war developed iron-clads, monitors, torpedoes, and repeating rifles. When Prussia and Austria met as foes, their struggle taught nations the value of breech-loading small arms, and we now have the hostilities between France and Prussia evoking the capabilities of the mitrailleur.

It is with this weapon that our present remarks mainly have to do—not, however, the mitrailleur as in use in the French army, but one which is now being tried in England, and which is attracting considerable attention just now. And, first, a few words in brief as to the history of this arm, whose name carries such terror with it. If our readers will turn to page 270 of our third volume, they will there find an illustrated description of the Gatling gun, one of the earliest of this class, and the general principles of which are embodied in the mitrailleur. These principles are a group of barrels banded together, a breech arrangement for rapid loading and firing, and means for vertical and horizontal training. About the same time that the Gatling gun appeared, or shortly afterwards, we had the Belgian mitrailleur, the invention of M. Montigny. Subsequently to this again, there appeared in France a similar weapon, invented by M. Manceaux, although, we believe, the weapon used in the present war is that of M. Montigny, with some slight alterations in the rifling and ammunition. Prussia and Austria procured samples of the Belgian arm and placed it in the hands of committees. No steps, however, were taken by England in the matter until Major Fosberry, V. C. stirred up the question, and went to Belgium to study the weapon. Satisfied with its capabilities, when properly constructed, Major Fosberry at once set about improving it, for he found it roughly made, the rifling bad, and the ammunition defective. Having obtained its recognition by our Government, a mitrailleur was constructed, into which numerous detail improvements were introduced by Major Fosberry, and this weapon has recently been the subject of some preliminary experiments at Shoeburyness.

Before noticing these experiments and their results, it may be as well to give a general description of the Fosberry mitrailleur. A detailed description it is neither possible nor expedient to give at present, inasmuch as on visiting Shoeburyness a day or two since we found the mitrailleur had been taken to pieces in order to make various slight alterations, the necessity for which had been rendered apparent by the recent practice. And it is possible that still further alterations will have to be made before the weapon is perfect, so that, under the circumstances, we wonder the authorities allowed the public to see it at all; their courtesy certainly deserves acknowledgment. The Fosberry mitrailleur consists of a compound barrel, composed of 37

TABLE OF RESULTS.

First Day's Experiments—Series 1 *to* 12.

Number of Series.	Name of Weapon.	Range in Yards.	Nature of Fire.	Number of Rounds Fired.	Time in Minutes.	Total Number of Hits.	Number of Men placed *hors de combat.* Cavalry	or Infantry.	REMARKS.
					m. s.				
1	Mitrailleur .	800	volley	6	2 00	110	38	45	Eight cartridges failed.
2	Mitrailleur .	800	quick file	5	1 00	154	59	49	Three cartridges failed.
3	Muzzle-loading field gun 9-pdr.	800	....	5	2 00	118	24	27	Shrapnel fuzed with wood, time fuzes, One burst too short for effect, and one burst through the target.
4	Ditto.....	800	....	8	2 00	115	45	51	
5	Breach-loading field gun 12-pdr.	800	....	6	2 00	38	15	18	Segment shells and C percussion fuzes. Two shells burst behind targets.
6	Ditto.....	800	....	5	2 00	15	8	5	Shrapnel shells and time fuzes. Two rounds 200 yards short, two over, one *nil* from fuze blowing. All high in air at burst.
7	Mitrailleur .	600	File with horizontal motion	6	2 00	127	61	57	Sixteen cartridges failed.
8	9-pounder .	600	....	7	2 00	283	68	88	Shrapnel and wood time fuzes.
9	12-pounder .	600	....	7	2 00	142	48	58	Shrapnel and time fuzes.
10	Mitrailleur .	300	File with horizontal motion	5	2 00	171	60	69	
11	9-pounder .	300	....	10	2 00	208	75	79	Case shot, 120 bullets each.
12	12-pounder..	300	....	9	2 00	268	91	111	Case shot.

Second Day's Experiments—Series 13 *to* 24.

Number of Series.	Name of Weapon.	Range in Yards.	Nature of Fire.	Number of Rounds Fired.	Time in Minutes.	Total Number of Hits.	Cavalry	or Infantry.	REMARKS.
13	Mitrailleur..	400	Sharp file with horizontal motion	6	2 00	178	73	84	
14	12-pounder..	400	....	9	2 00	168	72	79	Case shot. Tenth round not got off; miss-fire of friction tube.
15	9-pounder..	400	....	11	2 00	236	77	86	Case shot.
16	9-pounder..	400	....	7	2 00	144	54	66	Shrapnel, with five seconds' fuze cut to 1½ seconds to test results in comparison with case.
17	Mitrailleur..	400	single shots...	5	3 50	177	83	74	Deliberate firing. Horizontal training; 185 bullets thrown.
18	9-pounder..	400	....	5	1 14	110	52	59	550 bullets thrown
19	12-pounder..	400	....	7	..	118	47	58	Case shot; 9 not taken; 2 cases did not break up; 690 bullets thrown.
20	Mitrailleur..	300	single shots...	5	2 55	172	92	83	Horizontal training; 185 bullets thrown.
21	Ditto......	600	Single shots and a volley	5	1 55	107	49	52	185 bullets thrown.
22	Ditto.....	800	Ditto.....	5	1 45	106	40	45	185 bullets thrown.
23	12-pounder..	300	....	6	1 50	138	58	59	Case shot. One round did not break up.
24	9-pounder..	300	....	5	1 05	162	58	64	Firing case; 550 bullets thrown.

rifled tubes, each of which is about the size of an ordinary Enfield rifle barrel. These tubes are hexagonal on the outside, and are thus closely fitted together, the whole series being enclosed in a cylindrical iron casing and forming one weapon. The barrels are open at the breech ends, and are closed by a breech block, which, for loading, is drawn back, and a metal plate containing 37 central fire cartridges is inserted vertically. The firing apparatus is carried in the breech block, and consists of 37 pistons or strikers, each actuated by a spiral spring. After the metal plate containing the cartridges has been inserted, the breech

block is pressed forward by a lever, the cartridges being thus forced forward into the chambers of the barrels. The act of closing the breech block places the springs of the strikers in tension, and they are freed by the descent of a serrated shutter actuated by a firing lever. According as this lever is worked, quickly or slowly, the firing is either like volley firing or file firing, or even single shots can be made. The mitrailleur, at the same time, can be trained horizontally so as to traverse the whole front of an advancing column. The mitrailleur is mounted on a timber field carriage, which, although full heavy for it, gives its steadiness and absorbs the recoil; a lighter carriage, may, however, yet be adopted. The cartridges used were metal-cased and paper-covered, having a central fire, and generally resembling the Boxer cartridges used for the Snider rifle.

The experimental trials commenced on the 11th instant, and were continued throughout that and the following day. They were comparative, being carried on against the 12-pounder breech-loading rifled field gun, and the 9-pounder muzzle-loading (Maxwell) Indian bronze field piece. The design was to ascertain the relative powers of the mitraileur and the field guns for repelling an attack of infantry or cavalry advancing in line or column. With this view a line of wooden targeting, on which 150 infantry in front of 90 cavalry were depicted in outline. The ranges were 300, 400 600, and 800 yds. respectively, and the shooting was at first made against time at known ranges, no allowance being made for any hitches in handling or in the service of the several weapons. Two minutes' time was allowed in each case. The annexed Tables show the results of each day's proceedings at a glance, the details of the actual practice being given. There were 12 series each day, or 24 series in all.

It is worthy of note that this is the first occasion on which shrapnel shell has been fired at such short ranges. At the commencement of the series No. 16, only one of all the figures on the target remained unhit. This one was struck during that practice by a splinter on the cheek. The practice for rapidity was included in series 1 to 16, after which the previous series were repeated deliberately in order to eliminate failures due to premature or bad fuzes, defects in mitrailleur ammunition, and other unforeseen circumstances. Taking the results of the experiments as they stand, they are not altogether satisfactory as regards the mitrailleur so far as they have gone. It was said that the mitrailleur could accomplish 10 rounds per minute, whereas it has as yet only delivered 3. The 9-pounder field-gun—a muzzle-loader—gave 11 rounds in two minutes; whilst the mitrailleur never got off more than 6. But it is to be borne in mind that the latter weapon is not working with its maximum effect. The cartridges are not properly adapted to the gun, and cause delays both in loading and in withdrawing the cases. Sometimes the cartridges stuck in the chambers; at others the burr of the metal foil round the bullet caused the crumpling up of the cartridge case, and prevented the breech block closing. A metal case without any paper or other coating would probably do away with all these obstructions. Again, if we look at the number of bullets thrown in a given time, we do not find in the mitrailleur such a preponderance as we might have expected. Six discharges, accomplished in two minutes, deliver 222 bullets; the Indian gun, however, firing case shot, launches 110 bullets at each discharge, and as this gun has fired ten rounds in two minutes, we thus have 1,100 bullets delivered, or about five times as many bullets as discharged by the mitrailleur. The latter arm, however, shows a much higher percentage of hits than the field gun, and this with all the drawbacks attendant upon the unsuitable cartridges. The fact is, the Fosberry Mitrailleur is only going through the experimental stage at the present time, and when certain minor defects of construction have been remedied, and suitable cartridges supplied, we may look for far better results. Properly developed, the mitrailleur will undoubtedly prove one of the most powerful and useful weapons modern times have seen.

CERIUM.—This metal was discovered by Berzelius and by Kloproth, in 1803, in a peculiar ore found in an iron mine in Sweden. The name cerium was given because in the same year an asteroid had been discovered and called Ceres.

FORMULÆ FOR STRAINS IN TRUSSES, AND THEIR PRACTICAL APPLICATION.

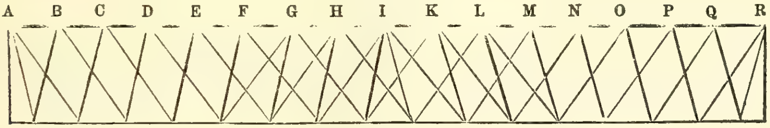
(*Continued from page* 216.)

The Whipple or Linville Truss, illustrated in Example 2d, is a compound truss, and in this respect differs very materially from the other examples. As there mentioned, it is a combination of two simple and similar trusses, which act, as far as all the members affected by vertical strains are concerned, entirely independently of each other. This independence is as complete as if they were on opposite sides of the bridge, and extends fully to the counterbracing. A separate consideration of these simple trusses renders the determination of the strains much easier. The superiority or greater lightness of a compound truss is owing largely to the division of the weight between two sets of struts. In a simple truss, one set of vertical and inclined members is subject to the whole weight.

Example 4th.

This, the Post Truss, is also a compound truss, but very different from Example 2d. The simple trusses of which it is composed act independently of each other only under a full load. The counterbracing connects them and a passing load is not equally divided between them as in the other case.

FIG. 14.



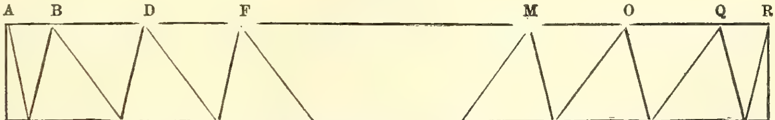
THE POST TRUSS.

The load is on the bottom chord, struts inclined with run of half a panel, and ties have a run of a panel and a half.

Omitting all the counterbracing, one simple truss is shown in Fig. 15.

This truss bears one half the load when

FIG. 15.



the bridge is fully loaded, but is irregular and has the weight unevenly distributed. The points k, m, and o, each bear a full panel load, but from Fig. 14 it may be seen that the point q bears half the load between q and r, and half the load between p and q, which is three-fourths of the load borne by the other points, k, m and o; and r bears directly one-fourth of a panel load. Eq. 11.

$$H' = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,l},$$

requires some change before application.

Let $l = 200$ ft., the length of the truss.
$d = 18.75$ ft., the depth of the truss.
$w = 150{,}000$ lbs., the weight of the truss.
$w' = 300{,}000$ lbs., the weight of a full uniform load.
$p = 12.5$ ft., length of panel of compound truss.

$x =$ distance of any one of the points q, o, m, k, from the right abutment.

$\frac{(w'+w)\,x}{4}$ is the moment of the abutment at any point, x. The moment of the load on the section x is

$$\frac{(w'+w)}{2\,l}\left(x-\frac{5\,p}{2}\right)\left(\frac{x}{2}-\frac{p}{4}\right)+\frac{p(w'+w)}{l}\left(x-\frac{3\,p}{8}\right),$$
$$=\frac{(w'+w)\,x^2}{4\,l}+\frac{(w'+w)\,p\,x}{4\,l}-\frac{(w'+w)\,p^2}{16\,l}$$

Whence

$$H = \frac{(w'+w)\,x}{4\,d} - \frac{(w'+w)x^2}{4\,d\,l} - \frac{(w'+w)px}{4\,dl} + \frac{(w'+w)\,p^2}{16\,d\,l} \qquad (31)$$

This equation gives the horizontal strains in the upper chord of Fig. 15, in

the members opposite the points k, m, o, and q.

To find the strains in the lower chord of the same simple truss, let x' represent the distance of any one of the points Q, O, M, and K from the right abutment; the moment of the load on x' is

$$\frac{(w'+w)}{2l}(x'-p)\left(\frac{x'}{2}-p\right)+\frac{p\,(w'+w)}{l}\left(x'-\frac{3\,p}{8}\right)$$
$$=\frac{(w'+w)\,x'^2}{4\,l}+\frac{(w'+w)\,p\,x'}{4\,l}+\frac{(w'+w)p^2}{8\,l},$$

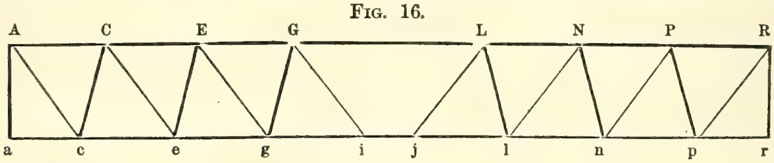
Whence

$$\mathrm{H}=\frac{(w'+w)\,x'}{4\,d}-\frac{(w'+w)x'^2}{4\,d\,l}-\frac{(w'+w)\,p\,x'}{4\,d\,l}-\frac{(w'+w)\,p^2}{8\,d\,l}\qquad(32)$$

The amount of horizontal strain in the members of the lower chord opposite the points Q, O, M and K.

Omitting all counterbracing, the other truss is shown in Fig. 16.

FIG. 16.



This truss bears the same weight as the other, but no part of the weight rests directly on r, but is borne equally by the points j, l, n and p.

The moment of the abutment is $\frac{(w'+w)x''}{4}$, x'' being the distance of any of the points j, l, n and p, from the right abutment.

For strains in the upper chord, the moment of the load on the section x'' is,

$$\frac{(w'+w)}{2\,l}\left(x''-\frac{3\,p}{2}\right)\left(\frac{x''}{2}+\frac{p}{4}\right)$$
$$=\frac{(w'+w)x''^2}{4\,l}-\frac{(w'+w)\,px''}{4\,l}-\frac{3\,(w'+w)p^2}{16\,l}$$

Whence,

$$\mathrm{H}=\frac{(w'+w)\,x''}{4\,d}-\frac{(w'+w)\,x''^2}{4\,d\,l}+\frac{(w'+w)\,p\,x''}{4\,d\,l}+\frac{3\,(w'+w)\,p^2}{16\,d\,l}.\qquad(33)$$

The amount of horizontal strain in the upper chord members opposite the joints j, l, n and p.

For strains in the lower chord, x''' being the distance of any one of the points L, N and P, from the right abutment,

$$\mathrm{H}=\frac{(w'+w)x'''}{4\,d}-\frac{(w'+w)x'''}{2\,d\,l}\left(\frac{x'''}{2}-\frac{p}{2}\right)$$
$$=\frac{(w'+w)x'''}{4\,d}-\frac{(w'+w)x'''^2}{4\,d\,l}+\frac{(w'+w)\,p\,x'''}{4\,d\,l}\qquad(34)$$

The strains in the upper chord of the compound truss can be obtained by adding equations (31) and (33), making x of one equation equal to $x+p$ of the other, as in Example 2d. In the Whipple Truss, however, the result was the same; if $x+p$ was substituted in either of the equations for the horizontal strains in the upper chord of the simple truss and then added to the other, we obtained only one equation for the horizontal strains in one chord. But this is not true in the Post truss; if x'' of equation (33) be made equal to $x+p$ and added to equation (31) we obtain a different result from what is obtained when x is made equal to $x''+p$ and the two equations then added. We have, therefore, two equations for the horizontal strains in the upper chord, one for the values of x, the other for the values of x''. In like manner, we have two equations for the lower chord, one for the values of x', the other for the values of x'''.

Making x'' of equation (33) equal to $x+p$ of equation (31), and adding the two, we obtain

$$\mathrm{H}=\frac{(w'+w)x}{2}-\frac{(w'+w)x^2}{2\,d\,l}+\frac{(w'+w)\,p}{4\,d}-\frac{(w'+w)\,p\,x}{2\,d\,l}+\frac{(w'+w)\,p^2}{4\,d\,l}\qquad(35)$$

for the strains in the upper chord of full truss opposite q, o, m, k, h, f, d, and b.

Substituting the values of the constants, we get

$\mathrm{H}=11250\,x-60x^2+79687.5.$

When $x=6.25$

$\mathrm{H}=70312\ 5-2343.75+79687.5=147$-656.25 lbs.

Compression in Q R and A B.

The next value of x in this equation is 31.25.

$\mathrm{H}=351562.5-58593.75+79687.5=372$-656.25 lbs.

Compression in O P and C D.

The next value of x is 56.25.

$\mathrm{H}=632812.5-189843.75+79687.5=$ 522656.25 lbs.

Compression in M N and E F.

The next value of x is 81 25

$\mathrm{H}=914062\ 5-396093.75+79687.5=$ 597,656.25 lbs.

Compression in K L and G H.

In equation (31) make $x = x'' + p$, add the equation so changed, to equation (33) and we obtain

$$H = \frac{(w' + w) x''}{2 d} - \frac{(w' + w) x''^2}{2 d l} - \frac{(w' + w) p x}{2 d l} + \frac{(w' + w) p}{4 d} - \frac{(w' + w) p^2}{4 d l} \quad (36)$$

for the strains in the upper chord of the compound truss opposite the points of single truss (Fig. 16) *p*, *l*, *n*, *j*, *i*, *g*, *e*, and *c*.

Substituting the values of the constants, we have

$H = 11250\,x'' - 60\,x''^2 + 70312.5$.

Giving x'' its first value, 18.75.

H=210937.5−21093.75+70312.5=260156.25 lbs.

Compression in P Q and B C.

The next value of x'' is 43.75.

H = 492187.5−114843.75+70312.5 = 447656.25 lbs.

Compression in N O and D E.

The next value of x is 68.75.

H = 773437.5 − 283593.75 + 70312.5 = 560156.25 lbs.

Compression in L M and F G.

The next value of x'' is 93.75.

H = 1054687.5 − 527343.75 + 70312.5 = 597656.25 lbs.

Compression in I K and H I.

In adding equations (32) and (34) to obtain the tensions in the lower chord of the double truss, we must, for similar reasons as before, make x in one equation equal to $x - p$ in the other equation, to obtain the tension opposite the points in that simple truss to which the latter equation belongs.

In equation (34) make $x''' = x' - p$ of equation (32), add the two equations and we obtain

$$H = \frac{(w' + w) x'}{2 d} - \frac{(w' + w) x'^2}{2 d l} - \frac{(w' + w) p}{4 d} + \frac{(w' + w) p x'}{2 d l} - \frac{5 (w' + w) p^2}{8 d l} \quad (37)$$

for the strains in the lower chord opposite the points Q, O, M, K, H, F, D and B.

Substituting the values of the constants,

$H = 12750\,x' - 60 x'^2 - 86718.75$.

The first value of x' is 12.5.

H = 159375 − 9375 − 86718.75 = 63281.25 lbs.

Tension in *b c* and *p q*.

Next value of x' is 37.5.

H = 478125−84375−86718.75 = 307031.25 lbs.

Tension in *n o* and *d e*.

Next value of x' is 62.5.

H = 796875−234375−86718.75 = 475781.25 lbs.

Tension in *l m* and *f g*.

Next value of x' is 87.5.

H = 1115625−459375−86718.75=569531.25 lbs.

Tension in *j k* and *h i*.

In equation (32) make $x' = x''' - p$ of equation (34), add the two equations and we obtain

$$H = \frac{(w' + w) x'''}{2 d} - \frac{(w' + w) x'''^2}{2 d l} - \frac{(w' + w) p}{4 d} + \frac{(w' + w) p x'''}{2 d l} - \frac{(w' + w) p^2}{8 l d} \quad (38)$$

for strains in the lower chord opposite the points P, N, L, I, G, E, and C.

Substituting the values of the constants,

$H = 12750\,x''' - 60\,x'''^2 - 77343.75$.

The first value of x''' in this equation is 25.

H = 318750 −37500 − 77343.75 = 203906.25 lbs.

Tension in *o p* and *c d*.

Next value of x''' is 50.

H = 637500−150000−77343.75 = 410156.25 lbs.

Tension in *m n* and *e f*.

Next value of x''' is 75.

H = 956250−337500−77343.75 = 541406.25 lbs.

Tension in *k l* and *g h*.

Next value of x''' is 100,

H = 1275000−600000−77343.75 = 597656.25 lbs.

Tension in *i j*.

In Example 2d the calculation of the vertical strains was a very simple operation as equation (25) had only to be divided by 2. In the truss under consideration the simplest method will be, first to ascertain the constant strains resulting from the weight of the truss alone, and afterward the strain from the passing load.

For the truss in Fig. 15, the vertical equation (14) assumes the form

$$V = \frac{w}{4} - \frac{w}{2 l}\left(u + \frac{p}{2}\right) \quad (39)$$

u being the distance from the abutment to a point midway between the loaded points or ends of the panels of the simple truss.

For the truss in Fig. 16 equation (14) assumes the form

$$V = \frac{w}{4} - \frac{w}{2 l}\left(u' - \frac{p}{2}\right) \quad (40)$$

u' being the distance to the centre of any panel of this truss.

Substituting the values of the constants in equation (39),

$$V = 37500 - 375\left(u + \frac{p}{2}\right).$$

In panel k M m, $u + \frac{p}{2} = 75$.

Whence V = 9375 vertical strain in panels k M m and h F f and their members k M, M m, h F and Ff.

9375 × 1 414 (secant of the angle of the ties) = 13256.25 lbs.

Tension in k M and h F.

9375 × 1.0541 (secant of the angle of the struts) = 9882.19 lbs.

Compression in M m and F f.

Next value of $u + \frac{p}{2} = 50$.

V = 18750.

18750 × 1.414 = 26512 5 lbs.

Tension in m O and f D.

18750 × 1.0541 = 19764.37 lbs.

Compression in O o and D d.

Next value of $u + \frac{p}{2} = 25$.

V = 28125.

28125 × 1.414 = 39768.75 lbs.

Tension in o Q and d B.

28125 × 1.0541 = 29646.56 lbs.

Compression in Q q and B b.

In part of panel q R r.

$u = o$ and V = 35156.25 lbs.

Compression in A a and R r.

35156.25 × 1 0541 = 37058.2 lbs.

Tension in q R and Ab.

In truss, Fig. 16,

$u' - \frac{p}{2}$ has the same values as $u + \frac{p}{2}$

and when $u' - \frac{p}{2} = 75$.

13256.25 lbs. Tension in j L and G i.
9882.19 lbs. Compression in L l and G g.

Next value of $u' - \frac{p}{2} = 50$.

26512.5 lbs. Tension in l N and g E.
19764.37 lbs. Compression in N n and E e.

Next value of $u' - \frac{p}{2} = 25$,

39768.75 lbs. Tension in n P and e C.
29646.56 lbs. Compression in P p and C c.

In panel p R r,

$$u' - \frac{p}{2} = 0, \therefore V = 37500$$

37500 × 1.414 = 53025 lbs.

Tension in p R and c A.

37500 lbs. is the vertical compression from this simple truss upon the end posts A a and R r, which added to the strain from the other simple truss, 35156.25 lbs., gives 72656.25 lbs. as the compression upon the end posts from the weight of the compound truss.

It will be remembered that the vertical strains, in the above cases, affecting the members to the left of the centre, have the minus sign, as u and u' have been measured from the right abutment.

Let the load be brought on at the left abutment, $\frac{w'(l-u)^2}{2\,l^2}$ is the weight passing to the right abutment, u being the distance of the end of the load from the right abutment, and $l-u$, consequently, is the portion of the truss which is loaded. The values of u are confined to the centres of the panels of the compound truss.

It will be seen from the plan of the truss, Fig. 14, that the passing load, before reaching the centre, transmits that portion of its weight which is borne by the right abutment, through the counterbraces, from one of the simple trusses to the other.

As shown before, the point where counterbracing becomes necessary, is where the portion of the passing load, $\frac{w'(l-u)^2}{2\,l^2}$, before it reaches the centre that goes to the farther abutment, is equal to the vertical strain of the constant load $\left(\frac{w}{2} - \frac{w\,u}{l}\right)$ that passes to the other nearer abutment; but in this case the vertical strain of the constant load is divided into equal separate parts, while the passing load is not divided; counterbracing will therefore become necessary when

$$\frac{w'\,(l-u)^2}{2\,l^2} = \frac{w}{4} - \frac{w\,u}{2\,l},$$

for then the load borne by the right abutment begins to be greater than the strain to the left abutment from the constant load of either of the simple trusses, and the difference must be transmitted by a counterbrace to the other simple truss.

a, therefore, becomes equal to 4 in equation (26).

$$l-u = \frac{l}{a} - l\sqrt{\frac{1}{a} + \frac{1}{a^2}} - l = 200.$$

Whence $l-u = 61.80$.

or counterbracing will become necessary at 61.8 feet from the abutment. This will be within the load on five panels. Making $l-u = 62.5$ and substituting the values of the constants in $\frac{w'\,(l-u)^2}{2\,l^2}$ we obtain 14648.44 lbs., the part of the load which passes to the right abutment; but in panel f F h this strain meets 9375 lbs. passing to the left abutment, leaving 14648—9375 = 5273.44 lbs. for the vertical strain on f G, the first counterbrace.

5273.44 × 1.414 (secant of the angle of the counterbrace) = 7456.64 lbs., longitudinal tension in the counterbrace f G and the corresponding one L m.

Bringing the load on to the centre of the next panel,

$$l-u = 75,\ V = 21093\ 75\ \text{lbs.},$$

vertical strain to the right abutment, meets 9375 lbs. in panel g G i passing to the left, and 21093.75 - 9375 = 11718.75 lbs. the vertical strain in g H and h H, and the corresponding braces on the other side of the centre, l k and K k. These four braces by the peculiar construction of the truss can never act except as counterbraces.

11718.75 × 1.414 – 16570.31 lbs.
Tension in g H and l K.

Advancing to the centre of the next panel,

$l-u$ = 87.5, and V = 28710.94 lbs.

In the panel h H j there is no vertical strain from the weight of the bridge, consequently

28710.94 × 1.414 = 40597.27 lbs.
Tension in h I and k I.
28710.94 × 1.0541 = 30264.2 lbs.
Compression in I i or I j.

This strain may pass through either of these struts, or may be divided evenly or unevenly between the two. Each therefore must be proportioned to bear the whole strain.

Advancing another panel,

$l-u$ = 100, and V = 37500 lbs.

There is no vertical strain from the bridge at this point.

37500 × 1.414 = 53025 lbs.
Tension in i K and j H.

This is supposing all the strain to pass down the strut I i, but with the exception of the load upon i, it may pass down the strut I j.

37500 × 1.0541 = 39528.75 lbs.
Compression in k K and H h.

Advancing another panel,

$l-u$ = 112.5, V = 47460.94 lbs.

The whole of this except the load upon i (18750 lbs.) may pass through the tie j L.

(47460.94 – 18750) × 1.414 = 40597.27 lbs.
Tension it j L from the passing load;

to which must be added the tension from the weight of the truss, 13256.25 lbs., and we have 53853.52 lbs. for the greatest tension to which j L and the corresponding tie i G are subject.

In like manner,

(28710.94 × 1.0541) + 9882.19 = 40146 lbs.
Compression in L l and G g.

Advancing another panel,

$l-u$ = 125, V = 58593.75 lbs.

All of which except the load upon j, 18750 lbs., may pass through k M; deducting this and adding truss strain,

(58593.75 – 18750) × 1.414 + 13256.25 = 69595.35 lbs.
Tension in k M and h F.
(58593 75 – 18750) × 1.0541 + 9882.19 = 51881.48 lbs.
Compression in M m and F f.

Advancing another panel,

$l-u$ = 137.5, V = 70898.44 lbs.

From which deduct the two panel loads on i and k (37500 lbs.), and add the truss strains as before.

(70898.44 – 37500) × 1.414 + 26512.5 = 73737.89 lbs.
Tension in l N and g E.
(70898.44 – 37500) × 1.0541 + 19764.37 = 54968.66 lbs.
Compression in N n and E e.

Advancing another panel,

$l-u$ = 150, V = 84375 lbs.

From which deduct the panel loads on j and l, and add the truss strains as before,

(84375 – 37500) × 1.414 + 26512.5 = 92793.-75 lbs.
Tension in m O and f D.
(84375 – 37500) × 1.0541 + 19764.37 = 69175.-3 lbs.
Compression in O o and D d.

Advancing another panel,

$l-u$ = 162.5, V = 99023.44 lbs.

Of which, only the loads on j, l, and n = 56260 lbs., can affect n P. Multiplying and adding truss strains.

(56250 × 1.414) + 39768 75 = 119306.25 lbs.
Tension in n P and e C.
(56250 × 1.0541) + 29646.56 = 88949.68 lbs.
Compression in P p and C c.

Advancing another panel,

$l-u$ = 175, V = 114843.75 lbs.

From which deduct the weight on j, l and n = 56250 lbs., and add the truss strains.

(114843 75 – 56250) × 1.414 + 39768 75 = 122620.31 lbs.
Tension in o Q and d B.
(114843.75 – 56250) × 1.0541 + 29646.56 = 91410.25 lbs.
Compression in Q q and B b.

Advancing another panel,

$l-u$ = 187.5, V = 131835.94 lbs.

Of which only the panel loads on j, l, n and $p = 75000$ lbs., can affect p R. Add truss strains,

$$(75000 \times 1.414) + 53052 = 159102 \text{ lbs.}$$
Tension in p R and c A.

Advancing the end of the load to a point midway between q and r,

$$l - u = 196.875, \ V = 145349.12 \text{ lbs.}$$

From which deduct panel loads on j, l, n and $p = 75000$ lbs., and add the truss strains,

$$(145349.12 - 75000) \times 1.0541 + 37058.2 = 111213.2 \text{ lbs.}$$
Tension in q R and b A.
$$145349.12 + 72656.25 = 218005.37 \text{ lbs.}$$
Compression in end posts R r and A a.

We have now obtained all the strains that can affect the members of the Post Truss, and have given formulæ that can be applied to similar trusses of different dimensions.

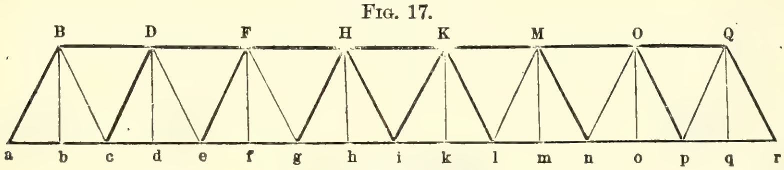
Some marked peculiarities of this truss deserve notice.

The extent of the upper chord affected by the maximum strains.

The unusual amount of counterbracing required, 8 counter-ties and 4 counter-struts being necessary in the example we have given. From these causes the weight of the central portion of this truss is proportionately heavier than the similar part of almost any other truss in general use. More of the load is borne directly by the truss than in the other examples. All these and other peculiarities are disadvantages when compared with other compound trusses. Compared with a Murphy Whipple Truss, the compound structur of the Post Truss, gives it greater lightness, though the difference is comparatively small. Whatever may be the advantages of the claimed economical inclinations of the ties and struts, they are more than balanced by the difficulties arising from these very inclinations in the centre of the system, and the great amount of extra ties and struts or counterbraces, required to properly unite them.

*Example 5th**.

FIG. 17.



THE WARREN GIRDER.

This is one of the simplest and best forms of truss in use. Equations (11) and (25) apply without change. In the first, x is the horizontal distance from the abutment to the apex either at the upper or lower chord of any of the triangles, and equation (11) gives the horizontal strain in the opposite base, u in equation (25) is the distance to the centre of any inclined brace. A panel includes but one member subject to a strain having a vertical component. The vertical rods merely transfer one panel load to the upper chord.

Let $l = 200$ ft., the length of the truss.
$d = 18.75$ ft., the depth of the truss.
$w = 150.000$ lbs., the weight of the truss.
$w' = 300000$ lbs., the weight of a full uniform load.

Substituting the values of the constants in Eq. (11),

$$H = 12000\,x - 60\,x^2.$$
For first value of x, 12.5, H = 140625 lbs.
Tension in p q and a c.
For the next value of x, 25, H = 262500 lbs.
Compression in O Q and B D.
For the next value of x, 37.5, H = 365625 lbs.
Tension in n p and c e
For next value of x, 50, H = 45000 lbs.
Compression in M O and D F.
For next value of x, 62.5, H = 515625 lbs.
Tension in l n and e g.
For next value of x, 75, H = 562500 lbs.
Compression in K M and F H.
For next value of x, 87.5, H = 590625 lbs.
Tension in i l and g r.
For next value of x, 100, H = 600000 lbs.
Compression in H K.

In equation (25) substituting the values of the constants,

$$V = 75000 - 750\,u + 3\ 75\,(l-u)^2.$$
For first value of u, 6 25, V = 211084 lbs.
211084 × (1.20185 secant of the brace angle) = 253691 lbs.
Compression in Q r and a B.
When $u = 18.75$,
221297.8 lbs. Tension in Q p and B c.
When $u = 31.25$,
190312.9 lbs. Compression in O p and D c.

* From Iron Truss Bridges for Railroads.

When $u = 43.75$,
150735 lbs. Tension in O n and D e.
When $u = 56.25$,
132567 lbs. Compression in M n and F e.
When $u = 68.75$,
105807 lbs. Tension in M l and F g.
When $u = 81.25$,
80455 lbs. Compression in K l and H g.
When $u = 93.75$,
56513 lbs. Tension in K i and H i.
When $u = 106.25$,
33979 lbs. Compression in H i and K i.
When $u = 118.75$,
12853 lbs. Tension in H g and K l.
When $u = 131.25$,
-5713 lbs. Tension in F g and M l.

The same kind of strain these braces were subject to when the load covered the centre.

It will be remembered that equation (25) gives the weight on the abutment from which u is measured, when the result has the plus sign; and the character of the strain is determined by the inclination of the braces. K l, H g, K i and H i are the only braces subject to both tension and compression, or which act as counterbraces. All the others being subject to only one kind of strain.

The Warren Girder affords an illustration of the subject of counterbracing superior to any other form of truss, because the main braces act as counterbraces, and the strains passing in opposite directions neutralize each other in the same brace. In Col. Merrill's Triangular Truss, page 93, the braces of cast-iron are made hollow, with wrought iron ties passing through their cavities. Using his results, the figure being the same as that given above, and beginning with B C, his first double brace, the tension from the truss weight is 73125 lbs. The greatest compression on this brace is 1,322 lbs. from the passing load. Suppose now, instead of having a double brace, we have one that can act only as a tie. The result will undoubtedly be, not that this tie suffers compression, for compression and tension cannot exist in the same member at the same time, but that the strain in this tie is the difference between the amounts of compression and tension to which it is subject, or $73125 - 1322$. This being the greatest compression in this tie, and the tension in like manner being the least, and constant, it certainly is very evident that this brace can never act otherwise than as a tie.

In the same manner, from the same author's calculations, D c's minimum and constant compression is 61875 lbs., aad its maximum tension is 3966.1 lbs., or it cannot act otherwise than as a strut.

D e's minimum and constant tension is 50,625 lbs., its maximum compression 13,360 lbs., or it is always a tie.

F e's minimum and constant compression is 39,375 lbs., its maximum tension 12,896 lbs., or always a strut.

F g's minimum and constant tension 28,125 lbs., its maximum compression 28,303 lbs.

The difference, 178 lbs., is all the compression this tie can be subject to, and this is the first brace that can act as a counterbrace.

H g's minimum and constant compression is 16,875 lbs., maximum tension 26,003 lbs., the difference 9,128 lbs., is all the tension this brace can be subject to.

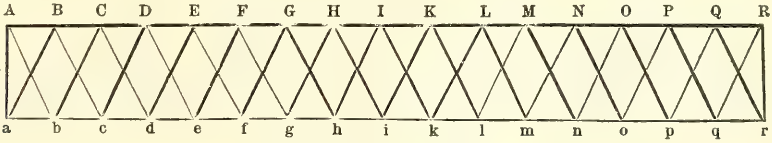
The last brace H i has a minimum and constant tension of 5,625 lbs., and a maximum compression of 46,448 lbs., the difference, 40,823 lbs., is all the compression this brace can be subject to.

From which we see that F g, H g and H i only can act as counterbraces.

Example 6th.

Let Fig. 18 represent a Lattice Truss, consisting of two systems of triangles, with the load traversing the lower chord.

FIG. 18.



THE LATTICE TRUSS.

This, like the Post and Whipple Trusses, is a double truss, and is composed of two Warren Trusses whose vertical strains are entirely independent of each other.

Separating them for a more easy con-

sideration of their strains, we have one truss, Fig. 19, bearing one half the load, and another truss of the form in Fig. 20, bearing the other half of the load.

Fig. 19.

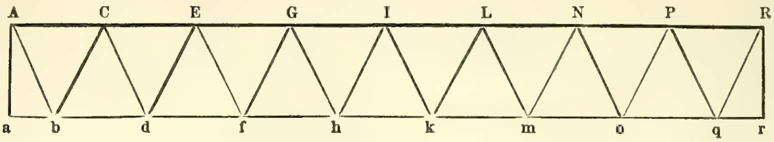
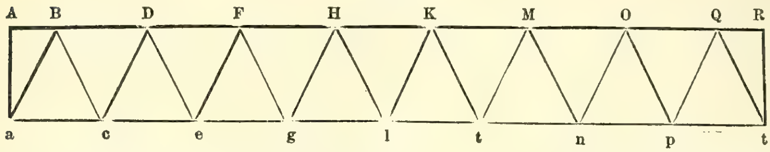


Fig. 20.



In Fig. 19, no weight rests directly on the abutment.

In Fig. 20, a half panel load must be considered as being borne directly by each abutment.

Let $l = 200$ ft., the length of the truss.
$d = 18.75$ lbs., the depth of the truss.
$w = 150000$ lbs., the weight of the truss.
$w' = 300000$ lbs., the weight of a full uniform load.
$x =$ distance of any apex in the compound truss from the abutment.
$u =$ distance midway between two loaded apices of either single truss from the abutment.
$p = 12.5$ ft., the distance between the apices of the compound truss or the length of a panel.

In Fig. 19, x being the distance of any apex in the upper chord from the abutment, equation (11)

$$H = \frac{(w'+w)\,x}{4d} - \frac{(w'+w)\,x^2}{4\,d\,l}$$

is the horizontal strain in the lower chord opposite that apex, $\frac{w'+w}{2}$ being the portion of the weight borne by that truss.

x' being the distance from the abutment to any apex in the lower chord.

$$H = \frac{(w'+w)\,x'}{4\,d} - \frac{(w'+w)}{2\,d\,l}(x'-p)\frac{(x'+p)}{2}$$
$$= \frac{(w'+w)\,x'}{4\,d} - \frac{(w'+w)\,x'^2}{4\,d\,l} + \frac{(w'+w)\,p^2}{4\,d\,l} \qquad (41)$$

will be the horizontal strain in the upper chord, opposite that apex.

In Fig. 20, x being the distance from the abutment of any apex in the upper chord, and $\frac{w'+w}{2}$ being the load borne by this truss.

$$H = \frac{(w'+w)\,x''}{4\,d} - \frac{(w'+w)\,px''}{2\,d\,l} - \frac{(w'+w)}{2\,d\,l}(x''-p)\left(\frac{x''-p}{2}\right) = \frac{(w'+w)x''}{4\,d} -$$
$$\frac{(w'+w)\,x''^2}{4\,d\,l} - \frac{(w'+w)\,p^2}{4\,d\,l} \qquad (42)$$

in the horizontal strain in the lower chord opposite that apex, and x''' being the distance from the abutment of any apex in the lower chord,

$$H = \frac{(w'+w)\,x'''}{4\,d} - \frac{(w'+w)\,x'''^2}{4\,d\,l} \qquad (43)$$

is the horizontal strain in the upper chord opposite that apex.

The value of H in one simple truss at x' added to the value of H in the other simple truss at $x'+p$ will give the amount of the horizontal strain in the upper chord of the double truss between x' and $x'+p$; and in the same way the value of H at x in one simple truss added to the value of H at $x-p$ will give the horizontal strain in the lower chord between x and $x-p$.

Adding upper chord equations (41) and (43) and making $x''' = x'+p$. (If x' be made equal to $x'''+p$ the result will be the same.)

$$H = \frac{(w'+w)x'}{2\,d} + \frac{(w'+w)\,p}{4\,d} - \frac{(w'+w)x'^2}{2\,d\,l} -$$
$$\frac{(w'+w)x'p}{2dl} - \frac{(w'+w)x'p^2}{8dl} + \frac{(w'+w)p^2}{8dl} =$$
$$\frac{(w'+w)}{2\,d}\left(x'+\frac{p}{2}\right) - \frac{(w'+w)}{2\,d\,l}\left(x'+\frac{p}{2}\right)^2 + \frac{(w'+w)p^2}{8\,d\,l} \quad (44)$$

Substituting the values of the constants,

$$H = 12000\left(x'+\frac{p}{2}\right) - 60\left(x'+\frac{p}{2}\right)^2 + 2343.75$$

$x'+\frac{p}{2}$ being the distance to the centre of any panel.

When $x'+\frac{p}{2}=6.25$, H = 75000 lbs.

Compression in Q R and A B.

When $x'+\frac{p}{2}=18.75$, H = 206250 lb.

Compression in P Q and B C.

When $x'+\frac{p}{2}=31.25$, H = 318750 lbs.

Compression in O P and C D.

When $x'+\frac{p}{2}=43.75$, H = 412500 lbs.

Compression in N O and D E.

When $x'+\frac{p}{2}=56.25$, H = 487500 lbs.

Compression in M N and E F.

When $x'+\frac{p}{2}=68.75$, H = 543750 lbs.

Compression in L M and F G.

When $x'+\frac{p}{2}=81.25$, H = 581250 lbs.

Compression in K L and G H.

When $x'+\frac{p}{2}=93.75$, H = 600000 lbs.

Compression in I K and H I.

Adding lower chord equations (11) and (42) and making $x''-p=x$. (If x'' be made equal to $x-p$ the result will be the same.)

$$H=\frac{(w'+w)x}{2d}-\frac{(w'+w)x^2}{2d}-\frac{w'+w)p}{4d}+\frac{(w'+w)px}{2dl}-\frac{(w'+w)p^2}{2d}=\frac{(w'+w)}{2dl}\left(x-\frac{p}{2}\right)-\frac{(w'+w)}{2dl}\left(x-\frac{p}{2}\right)^2-\frac{3(w'+w)p^2}{8dl} \qquad (45)$$

Substituting the values of the constants,

$$H=12000\left(x-\frac{p}{2}\right)-60\left(x-\frac{p}{2}\right)^2-7031.25$$

When $x-\frac{p}{2}=6.25$, H = 65625 lbs.

Tension in q r and a b.

When $x-\frac{p}{2}=18.75$, H = 196875 lbs.

Tension in p q and b c.

When $x-\frac{p}{9}=31.25$, H = 309375 lbs.

Tension in o p and c d.

When $x-\frac{p}{2}=43.75$, H = 403125 lbs.

Tension in n o and d e.

When $x-\frac{p}{2}=56.25$, H = 478125 lbs.

Tension in m n and e f.

When $x-\frac{p}{2}=68.75$, H = 534375 lbs.

Tension in l m and f g.

When $x-\frac{p}{2}=81.25$, H = 571875 lbs.

Tension in k l and g h.

When $x-\frac{p}{2}=93.75$, H = 590615 lbs.

Tension in i k and h i.

To ascertain the vertical strains, equation (25) is applicable to both simple trusses. It will avoid confusion to calculate the vertical strains of the simple trusses separately.

$$V=\frac{w}{4}-\frac{wu}{2l}+\frac{w'(l-u)^2}{4l^2}.$$

Substituting the values of the constants,

V = 37500 − 375u + 1.875 $(l-u)^2$ for either simple truss.

Since simple truss, Fig. 19, has the centre of the end panel at the end of the truss, the first value of V is, when $u=0$,

V = 112500 lbs., compression in end posts *R r* and *A a*.

112500 × 1.20185 (secant of brace angle) = 135208 lbs., tension in R q and A b.

When $u=25$, V × 1.20185 = 102815 lbs.

Compression in P q and C b.

Tension in P o and C d.

When $u=50$, V × 1.20185 = 73238 lbs.

Compression in N o and E d.

Tension in N m and E f.

When $u=75$, V × 1.20185 = 46478 lbs.

Compression in L m and G f.

Tension in L k and G h.

When $u=100$, V × 1.20185 = 22535 lbs.

Compression in I k and

Tension in I h when the left half of the truss is loaded, when the right half is loaded, there is the same compression in I h and tension in I k.

When $u=125$. V × 1.20185 = 1409 lbs.

Compression in *G h* and *L k*.

Tension in *G f* and *L m*.

When u is greater than 125, V has the minus sign and the braces beyond act only as main braces.

For simple truss Fig. 20, the first value of u is 12.5.

V = 98731 lbs. compression in end posts *R r* and *A a*. which added to the amount previously obtained gives 211231 lbs. total compression.

98731 × 1.20185 = 118660 lbs.

Compression in Q r and B a.

Tension in Q p and B c.

When $u=37.5$, V × 1.20185 = 87674 lbs.

Compression in O p and D c.

Tension in O n and D e.

When $u=62.5$, V × 1.20185 = 59506 lbs.

Compression in M n and F e.

Tension in M l and F g.

When $u=87.5$, V × 1.20185 = 34155 lbs.

Compression in K l and H g.

Tension in K i and H i.

When $u=112.5$, V × 1.20185 = 16429 lbs.

Compression in H i and K i.

Tension in H g and K l.

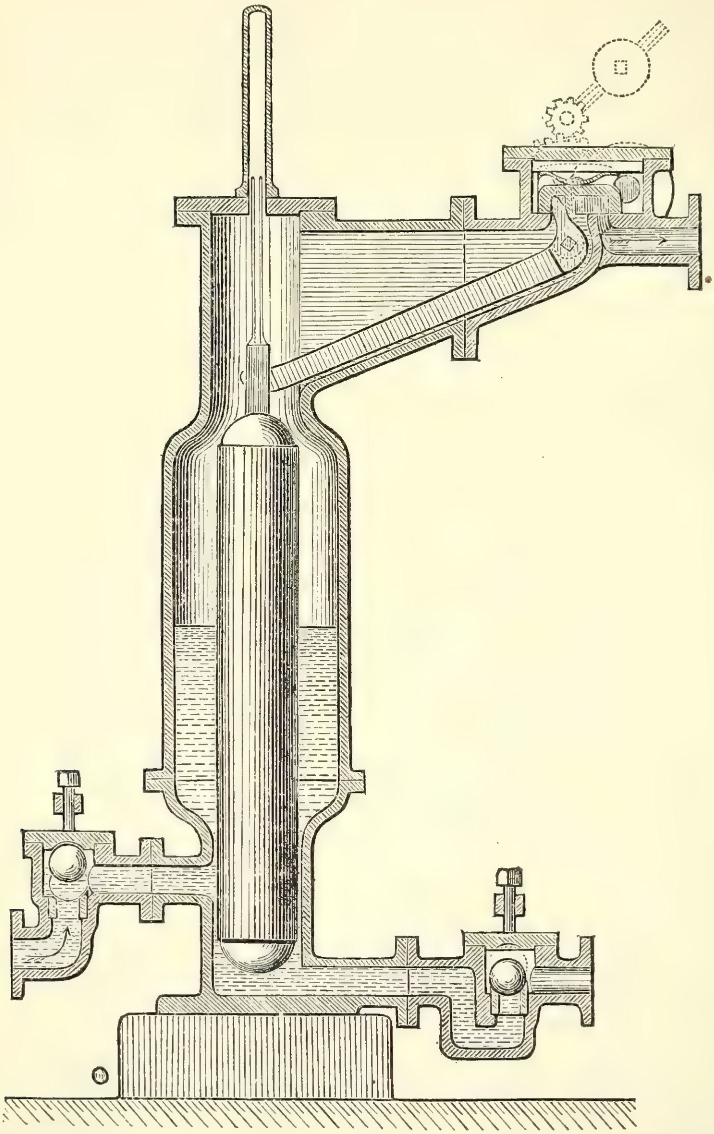
When u has a greater value, V indicates a strain affecting the other braces only as main braces.

G f, G h, I h, I k, L k, L m, H g, H i, K

i and K *l* only, act as counterbraces. A lattice truss, made of two or more simple Warren Trusses, properly proportioned and practically arranged, is undoubtedly one of the simplest, lightest, strongest and cheapest trusses in use.

AUTOMATIC BOILER FEEDER.

From "Revue Industrielle."



This new feeder of Macabies is designed to maintain a constant level in steam boilers. It is composed of a cylindrical receiver furnished with too spherical valves, one slide valve, and a floating water-gauge.

The receiver is put in communication first with the atmosphere and the hot

water of a reservoir, and then with the steam and water of the generator.

It is in reality a supply cylinder of small capacity, working automatically, and having no parts liable to derangement. The work of supplying the boiler is reduced to a simple surveillance of the apparatus.

When the float is down, as in the figure, the steam in the receiver can escape by the valve at the upper right-hand corner, and hot water from the proper reservoir flows in by the valve at the lower left-hand side. As the receiver fills, the float rises and closes the right-hand upper valve; the steam, then acting upon the water of the receiver, closes the valve which admits the supply and opens the valve upon the opposite side, which opens communication with the boiler. The water, being subjected to equal pressure above and below, flows into the boiler by virtue of its weight. The float descending with the water shuts the steam valve and the water again flows in.

This movement of the float continues until the end of the pipe supplying steam is covered by the water. The feeder then ceases to work, but resumes its action as soon as the steam is again free to act upon the water of the receiver.

The slide valve is worked by a bent lever, as shown in the figure; the axis of this lever is extended, and has fitted to it, on the exterior of the apparatus, a double sector, which serves to operate as a counterpoise. The object of this latter is to correct the too gradual movement of the float; it is so adjusted that the float does not commence its motion either up or down until the liquid surface has moved through considerable space; it then makes a complete stroke with an accelerating velocity.

In the smaller varieties of this instrument, a second counterpoise attached to the first sector is found to be necessary.

The pipe which conducts steam to the receiver terminates in a perforated cover, so as to avoid irregularities arising from too great disturbance of the water in the generator.

Compared with a feed-pump, this apparatus of Macabies presents some advantages. 1st. It works without aid of the engine, or special steam cylinder. 2d. It economizes 4 or 5 per cent. of the fuel. 3d. It cannot produce shocks to impair the working of the engine.

Compared with the Giffard injector, which also works without aid of the engine, it has the disadvantage of being less accessible to the fireman and also of having parts in motion during the filling; but, on the other hand, it can work with the water at 100 deg. Centigrade, and it operates without interruption, which compensates for the disadvantages enumerated.

In small boilers especially, supplied by the Giffard injector working at intervals, the pressure varies considerably, and the injector becomes uncertain in its action. With a difference of 70 deg. temperature between boiler and feed water, the Macabies feeder is much more efficient than Giffard's. Finally the employment of water at a high temperature will save the boiler largely from incrustations.

Colors of Gases in Geissler Tubes Changed by Magnetism.—M. Trève, in a late communication to the French Academy of Sciences, gives an account of his experiments with gases inclosed in glass tubes and exposed to a current of electricity, and at the same time to the influence of a powerful electro-magnet. Having taken a Geissler tube filled with hydrogen, one portion of the tube being drawn out to capillary thinness, he caused the induction current to pass through it, which, as is well-known, imparts to the gas in the thick part a blue color, tinged with violet, and in the capillary portion a brilliant red. Now if the latter be placed between the poles of the electro-magnet, the red at once disappears, and is converted into white light. In the case of oxygen, the capillary part is milky white; under the influence of electro-magnetism it becomes red. Under the same circumstances the blue of nitrogen becomes much darker, and the sparkling white of carbonic acid turns blue. Hence, so far, magnetism is found to destroy or change the color of a gas in the capillary part of a tube containing it.

The St. Louis "Review" says: Messrs. Bidwell & Blake, of the American Plate Glass Works, have arrived in New York from Europe, and are expected in St. Louis in a week to inaugurate the erection of their extensive works near this city.

PURIFICATION OF SEWAGE.

From "The Engineer."

It occasionally happens that the soundest theory will not work out in practice ; but it is delusive to imagine that a theory that is radically unsound will ever work out at all. Yet, there are people whom it is impossible to persuade of this fact, and nothing less than trial after trial, and experiment after experiment, will convince them of their error. Repeated failures of the most tangible and palpable nature are scarcely sufficient to open their eyes, and even when the results are incontestably erroneous, they remain in the position of men convinced against their will. So long as it is possible to cast the shadow of a doubt upon the evidence that weighs against them, or the allegations that may be put forward by their opponents, they uphold their opinion, and cling with the tenacity of fanaticism to the object of their idolatry. But as, notwithstanding the superstition of the devotees, all false beliefs must terminate eventually for lack of converts, so the votaries of a theory that is untenable, and a practice that is fallacious, will ultimately fail to enrol among their members those who are true believers. It is probable that some of the latter may be led away for a time by specious arguments, distorted facts, and apparent realities ; but in this age of rigid inquiry and investigation the inevitable exposure comes sooner or later. Those who once almost believed in the integrity of their scientific creed, subsequently blush for their credulity, and endeavor by the strength of their recantation to atone for their apostacy. Thus, in the end, the cause of truth prevails, and at whatever cost that object may be attained no one will repine at it but those who endeavored to prevent it. If these were the only people upon whom the cost was to fall it would be but a just retribution for their attempts to disseminate error ; but, unfortunately, the innocent are mingled with the guilty, and rates press heavily upon both.

It is now some years since we first ventilated in our columns the great national question of the day, and from that time to this we have advocated, with unflinching fidelity, the principle of sewage irrigation. There was then but very little encouragement to do so. The principle was altogether untried, if we except such instances as those which occur at Edinburgh. It was on its probation at Croydon, where it was not then the great success it is now, and many who participated in our views, theoretically regarded, were not bold enough to assert their belief in their practical application. Moreover, there was a host of hostile patentees and inventors of sewage nostrums in the field, who, while lauding to the skies the infallibility of their own individual panaceas, forgot their private differences, and made common cause against their common foe—the advocates of sewage irrigation. Another difficulty the latter had to contend against was, the comparatively circuitous course they were compelled to adopt in order to obtain a chance of demonstrating the correctness of their opinions. The first stumbling-block in their way was the necessity of procuring land for their purpose, which was a tedious and expensive, and sometimes an impossible affair. On the other hand, a few settling tanks and some mechanical and chemical appliances sufficed to put in working order the disinfecting and purifying apparatus. The relative cost, too, was all in favor of the nostrum party, and, moreover, they offered the alternative of abandonment on failure—an event which has happened pretty frequently—whereas, when land has been purchased and the necessary works constructed for irrigating it with sewage, the abandonment of the whole project is a thing not to be contemplated. Some of the favor which has been accorded by local boards to the various deodorizing and disinfecting processes is undoubtedly due to the fact of their being capable of merely temporary use, as they are readily erected, and, as reference has shown, more readily pulled down. Being convinced, after a careful examination, that the principle of sewage irrigation was they only one that offered a solution of the two great problems in connection with this momentous question, it remained for us to watch vigilantly for the results of actual practice.

The two great problems offered for solution are the purification of the sewage

so as to render the effluent or supernatant water sufficiently clear and unpolluted to pass into the nearest natural watercourse without contaminating it; and the manufacture of a salable manure. The success which has attended the adoption of the irrigation system at Croydon, Norwood and elsewhere, has fully and conclusively demonstrated that both these operations are perfectly effected through its instrumentality. Repeated analyses of the contents of those streams which are situated in close proximity to the outfall of the effluent water have shown them to be quite free from any sewage pollution, and that, in addition, the quantity of solid matter due to the discharge rarely exceeds two grains in the gallon. The manufacture of a salable manure from the residue in the reservoirs and settling tanks is comparatively of no importance, as the land is fertilized by the flowing of the liquid over it. Can it be said that a single one of the numerous so-called purifying processes has succeeded in securing either of these desiderata? After a perusal of the second report of the Rivers Pollution Commission it is unnecessary to ask the question.

Accepting the fact—which is too notorious to be contradicted—that all our rivers and streams are merely running sewers, it is only natural that preventive processes should have engaged the attention of, at any rate, chemists. We doubt whether the preparation of anti-sewage medicines can be strictly regarded as a legitimate professional occupation. The Commissioners, in their first report, reviewed the principal methods of treating sewage for the purpose of defecation and purification, and those who have perused it, will be aware that the lime process, and that termed the "A. B. C." process, were the two that were least objectionable of all those included in the common category. Both of these partially fulfilled the intended design, but the result in both instances fell very far short of what was not only desirable, but, on sanitary grounds, indispensable. The effluent water was not rendered sufficiently pure to be permitted to flow into a stream, and the manure manufactured was practically of little or no value. Since the issue of the report, the "A. B. C." process has been very prominently and very confidently advocated by the promoters, and has altogether superseded the lime process. This last may be, therefore, dismissed from consideration, and our attention concentrated on the other, more especially as a close and impartial investigation into its whole theory, *modus operandi*, and practical results, forms the subject of the second report of the Commissioners. To any one but the promoters of the scheme themselves this second inquiry would be totally unnecessary; but as they raised some objections to the first experiments, conducted at Leicester and Leamington, the Commissioners consented to give them another trial, although they had themselves a tolerably accurate anticipation of what would be the only conclusion they would arrive at. The objections to the first ordeal raised by the "A. B. C." gentlemen were that the results of the experiments were inconclusive, insomuch as accident had interfered with them at Leicester, and that at Leamington the weather had been wet and unfavorable. One is ready, on receiving a reliable explanation, to admit the validity of the first excuse, but by no means that of the second. If a process for effecting the disinfection and purification of sewage cannot be carried on in wet, or any other kind of weather, the sooner it is done away with the better. This would be a sufficient cause, in our opinion, to reject the whole project at once. It is in wet weather that the evil is greatest, and the remedy should be the most active. The Comm ssioners state plainly their own convictions that the objections of the promoters were futile, and that the circumstances complained of were not calculated in any manner to vitiate the experiments referred to. While we applaud the manifest candor and sense of justice and fair play displayed by those gentlemen in the execution of a public duty, we are not convinced that any necessity existed for incurring the expense of a second set of experiments, an opinion fully confirmed by the contents of the report. On the whole, it is perhaps just as well that the second trial has taken place, for it is conclusive, will set at rest for ever all doubts on the matter, and adds one more corroboration to the truth of the irrigation principle so strongly upheld by all our most eminent engineers.

It will be universally admitted that the purification, or the clarification, of the effluent water of sewage, is more impor-

tant to the sanitary welfare of the community than the production of an artificial manure from the solid residue; consequently the former must always be the first consideration, and any process that does not accomplish this is valueless, notwithstanding whatever might be the quality of the manufactured manure. The standard determined by the Commissioners with respect to admitting effluent sewage water into rivers is, "that any liquid containing in suspension more than one part by weight of dry organic matter in 100,000 parts by weight of the liquid" is not admissible. But the "A. B. C." process is not competent to reach this standard, as the average of the analyses of the samples taken on three consecutive days gave 2.82 parts of suspended organic matter in 100,000, or nearly three times the amount allowed. In every instance there is always left in solution a balance of solid matters, which is greater than the amount originally present in the sewage. It certainly strikes the observer as a somewhat paradoxical circumstance, to attempt to purify sewage by adding to it a large quantity of extraneous substances. The amount of the suspended organic matter is not of so much importance in the effluent water as the quantity of organic nitrogen, since it is the latter which, by reason of its highly putrescible nature, chiefly causes pollution in a stream. Unfortunately the process fails, not only to remove the organic nitrogen, but in fact actually increases the amount of it in solution. It has been stated before in our columns that the purification of the effluent water and the production of an artificial manure from the residue are complementary operations, the successful execution of the one necessitating that of the other. A mere glance at the evidence before us is more than enough to prove how inefficacious and crude is the "A. B. C." process. An inspection of the analytical tables demonstrates that the amount of total combined nitrogen, which very nearly represents the manure value, is greater in the effluent water than in the residue, thus in reality causing the former, which is intended shall flow away and be lost, to be a better manure than the raw sewage. The Commissioners remark, "this fact is very significant, as bearing upon the manufacture of manure by the 'A. B. C.' process, when it is remembered that seven-eighths of the manure value of sewage reside in the soluble constituents." After this no one will be surprised to learn that the artifically prepared manure, which is theoretically, or rather chemically, valued at 17s. per ton, barely realizes one. The remark is full of truth, that "without fortification with sulphate of ammonia, nitrate of soda, or superphosphate of lime, such manures are scarcely soluble."

The experiments at Leamington were, so far as the conclusions to be arrived at, a corroboration of those already come to after witnessing the previous one at Leicester. The effluent water was more impure than at the former place, and the yards around the buildings were covered with sewage mud spread out to dry. "The smell was extremely offensive, and the process would be pronounced a nuisance whenever conducted in or near a town." In addition, the filters were choked up, and masses of dark putrid mud, buoyed up by gas, occasionally rose to the surface and floated into the river. Altogether, to judge from the description in the report, the whole process at Leamington must be sufficiently disgusting, and the result is, "but a very slight purification of the sewage of that town." The effluent water discharged into the river Leam contained almost exactly as much soluble polluting matter as the raw sewage, although it had been treated with a proportion of the "A. B. C." mixture one-eighth greater than that presented by the specification. On some occasions, as much as double the specified quantity has been employed. The Commissioners' final remark, respecting the pretended purification by this system is, "On no occasion, even when mixed with more than four times its volume of clean river water, was the effluent sewage other than a polluting liquid, offensive to the senses even at the moment of discharge, and always quite unfit to be admitted into running water." Were any more tangible proof required to demonstrate that the attempted purification is a mere farce, it is to be found in the comparison of the state of the river above and below the outfall of the "A. B. C." works. Above the outfall the river was somewhat turbid, but on the whole presenting the appearance of an unpolluted stream. There were no *fungi* nor any indications of putrescence to be observed. Below, masses of putrid mud were drifting about

the surface; sewer *fungi* were growing abundantly on submerged objects near the bank, increasing notably in quantity as they approached the outfall. The artificially prepared manure is said to sell for £3 10s. per ton, but the evidence to support this statement may be well described to be "of the weakest kind." If this sum is given for it by the farmers they must be a most confiding race of bucolics, or guano must command a fabulous price in those parts. The "report" sums up by observing: "As, therefore, the inevitable conclusion is unfavorable to the 'A. B. C.' process in respect of its alleged power to hinder the pollution of rivers by town sewage, so also is it altogether unfavorable to the value of the manure which it manufactures."

The most strenuous and uncompromising adherents of all these patent anti-sewage panaceas must confess that they have one and all had a perfectly fair trial, and that they have all failed miserably to effect what they so pretentiously asserted they could accomplish. There is scarcely one of these quack methods which some unfortunate local board or other has not been seduced into experimenting upon, and all with the same result. We hope they can reconcile it to the ratepayers—and their own consciences. One by one they are renouncing them in favor of irrigation, and they have paid dearly enough for their experience. We have always advocated a fair trial for everything that will bear a sound investigation into its merits, even although our anticipations might tend to the conclusion that in practice it might be "found wanting;" but we trust that we shall hear of no more trials. It is time these delusions were terminated. A witness of high professional standing and unblemished integrity gave before the Commission his opinion of the "A. B. C." process. He said: "As regards its superior defecation of sewage, and the high value of the product yielded, I came to the conclusion that it was simply a juggle." The opinion is forcible, but the evidence, in the mind of any unbiassed person, tends more to prove than to disprove it. Land is the only defecator of sewage, and the sooner that truth becomes recognized the sooner will the report before us be acted upon. The Commissioners state: "We have therefore no hesitation in recommending irrigation as the only plan of dealing with the sewage difficulty at present known to us, which abates a nuisance and turns to profitable account an otherwise valueless material."

ON WIND FORCE.

From "The Mechanics' Magazine."

The quarterly weather report of the Meteorological Committee, which was noticed in the "Mechanics Magazine" for July 29, revives a discussion on the methods of arriving at the pressure or velocity of wind, which Admiral Fitzroy opened in the third number of "Meteorological Papers," published by the Board of Trade in 1858. The difficulties of the subject were then pointed out, and we are yet no nearer removing them. Let us hope that now it has attracted the attention of the scientific committee, a better status of certainty and uniformity of observation may be attained as regards the wind.

The anemographs erected at the several observatories are, we believe, perfectly similar instruments, identical in all respects, except as to the positions of exposure; but the anemogram plates show that the velocities registered at the three inland stations, Kew, Stonyhurst, and Armagh, fall very far short of those noticed at the coast observatories. Stonyhurst is 361 ft. above the sea, Armagh 207 ft.; nevertheless the inference is that the undulations of the land diminish even at considerable elevations the strength of wind by frictional resistance. The Meteorological Committee have erected an anemograph at the Sailors' Home, Yarmouth, on the beach. Eastward is the sea, westward the ground slopes slowly upward for about a quarter of a mile and then stretches away many miles as a perfectly flat plain. There is it is found that the velocity registered in westerly winds is about one-half of that registered in easterly winds, although the estimated force of wind at the St. Nicholas Gat lightship, at a distance of only two miles at sea, is equal for the two opposite points.

Since 1858 the Admiralty have enforced the usage of the following system of numbers for marking the strength of wind, as proposed by Sir F. Beaufort :—

0. Calm.
1. Light air, or just sufficient to give steerage way.

2. Light breeze	or that in which a well-conditioned man-of-war, with all sail set and clean full, would go in smooth water from	1 to 2 knots.
3. Gentle breeze		3 to 4 knots.
4. Moderate breeze		5 to 6 knots.
5. Fresh breeze	or that to which she could just carry in chase full and by	Royals, etc.
6. Strong breeze		Single-reefed topsails and topgallant sails.
7. Moderate gale		Double-reefed topsails, jibs, etc.
8. Fresh gale		Triple-reefed topsails, etc.
9. Strong gale		Close-reefed topsails and courses.

10. Whole gale, or that with which she could scarcely bear close-reefed maintopsail and reefed foresail.
11. Storm, or that which would reduce her to storm-staysails.
12. Hurricane, or that which no canvas could withstand.

However convenient this system may be for the abbreviation of nautical phraseology, it has the defect of not rising by equal units of velocity or pressure. Its general use in the Navy, its extensive use in the merchant service, and its gradual extension among observers on shore, render it desirable to insist upon the recognition of this defect. For the tendency is to overlook the fact that the grades of force progressively increase, and it has become the practice to use the figures so representing forces of wind for the purpose of determining the average wind force, by simply taking the arithmetical average irrespective of the different values of the grades. According to Sir W. Snow Harris winds similarly defined or designated have respectively, in round numbers, velocities of 3, 6, 10, 14, 17, 19, 21, 29, 48, 76, 90, and 114 miles per hour ; or pressures of 0.04, 0.14, 0.5, 0.9, 1.4, 1.7, 2.1, 3.7, 10.4, 26, 36, 57 lbs per. square foot.

Now to show the difficulty of dealing with estimates of wind statistically, let us suppose two notations of force, 4 and 10 ; these are velocities 14 and 76, or pressures 0.9 and 26 ; the averages are 7, 45, and 13.5 respectively, but the velocity corresponding to 7 is only 21 instead of 45, and the pressure 2.1, not 13.5. Before averages can be struck, therefore, the figures of the Beaufort scale should be converted into velocities, otherwise incongruity will result. Here, however, is precisely the difficulty. It is not admitted that Harris's equivalent velocities are sufficiently precise ; and it still remains to establish such a conversion table. From comparisons made between estimated force of wind and velocity recorded by anemograph at Holyhead Lighthouse the mean of 66 observations gives 36 miles an hour for force 6, and the mean of 55 observations gives 43.5 miles an hour for force 7, which are just about double the velocities assigned for the same winds by Harris. With reference to anemographical registration of wind, the various modes of estimating its force, strength, or pressure, require extensive investigation.

Since 1840 Mr. Glaisher, and the observers who act with him, have steadily employed the "land scale," so called, which considers the strength of wind by estimation to be reduced to pressures on the square foot, as follows :—

0.25	by estimation, is	1 oz.	pressure on the	sq. ft.
0.5	"	4 oz.	"	"
0.75	"	9 oz.	"	"
1.0	"	1 lb.	"	"
1.5	"	2¼ lbs.	"	"
2.0	"	4 lbs.	"	"
2.5	"	6¼ lbs.	"	"
3.0	"	9 lbs.	"	"
3.5	"	12¼ lbs.	"	"
4.0	"	16 lbs.	"	"
4.5	"	20¼lbs.	"	"
5.0	"	25 lb.s	"	"
6.0	"	36 lbs.	"	"

The formula is—
(Estimated force)^2 = pressure in lbs. on the sq. ft.

This system, says the "Weather Report," is obviously insufficient, at least in the case of storms; for whereas the highest pressure which is given is 36 lbs., and the corresponding velocity is 85 miles an hour, velocities and pressures respectively exceeding these values have been not unfrequently registered at our own observatories, and also by Mr. Hartnup at the Bidston Observatory. The wind in these islands may be safely asserted scarcely, if ever, to reach the force of 12 Beaufort scale. It can hardly be maintained that storms of the severity of tropical cyclones ever visit our coasts ; if they did, the damage done to buildings and vegetation would be far more serious than it is.

Lind's anemometer, which is intended to measure the force of wind by its effect in raising a column of water in an inverted glass siphon, is read off in inches of difference of level of the water in the two limbs, and the table he gave expresses the pressure as the absolute weight of water so sustained, supposing it to have a base

of a sq. ft.; thus 6 in. would equal 31.25 lbs., or half a cubic foot of water. But the resistance arising from the deflection of the air, and the difficulty of getting the current to act directly in such an instrument, practically render it useless. It is evident that its indications will be less than the truth. Admiral Fitzroy proposed to convert the land scale into the sea scale by doubling it, but this is evidently fallacious, as can be easily shown by an example: Take 3 by land scale; this is supposed to be equal to 9 lbs., which by the sea scale is about 9, or three times the land scale. Indeed, there is no relation between the two scales by a constant factor. There is nothing that we can perceive in favor of the land scale, unless it be that the square of the number gives the pressure.

The problem which meteorologists are called upon to solve is the relation between the indications of anemographs and the estimates of wind force, and to furnish a rule for converting one into the other. We are glad to notice that one important investigation will not escape the attention of the Meteorological Committee, which we infer from their statement, that "the periods for which contemporaneous records exist are far too short for us to determine the factor, if any such should exist, by which the velocity at each inland station should be multiplied in order to bring it up to its equivalent at a sea station."

The relation between velocity of wind and its pressure is another subject for experimental research; at present, authorities agree only to differ in the conversion formulæ which they employ.

IRON AND STEEL NOTES.

At a late meeting of the Engineers and Shipbuilders' Association, at Glasgow, Scotland, Mr. Wm. Ferrie read a paper "On the Utilization of Blast-Furnace Gases, Coal being used as Fuel." The utilization of gases from blast-furnaces had, the writer said, for many years attracted the attention of ironmasters; and in the Cleveland district, in particular, the consumption of these gases had arrived at a high degree of perfection. In districts where raw coal was the fuel used, nothing could be stated as to the results; and it had been said that a Scotch furnace sent twice as much unconsumed fuel into the air as was consumed within it. The difficulty in withdrawing the gases from a furnace using raw coal as the fuel was, that the combustion of the gases at the furnace-top was the means whereby the coal was converted into coke, in which state it must be previous to its descent to the zone of reduction. That the gases were in excess of what was required for the coking process was beyond doubt; but to regulate the withdrawal of them so as not to interfere with the regular workings of the furnace had never been done satisfactorily. Were a practicable plan introduced to admit of the withdrawal of the gases, the saving in fuel would be enormous, and amounting to something like 600,000 tons of coal per annum over the pig-iron furnaces of Scotland. In considering this subject, it occurred to the writer that, if they could coke the coal in furnaces in the same way as coal was coked in the common retorts at gas works, the difficulty would be overcome. He accordingly commenced experiments with a small blast-furnace, about the fifteenth capacity of a 50 ft. furnace. The upper part was divided into two compartments or retorts, into which the coal, ores and flux were charged, and the top was closed in the usual way by the bell and cone. The gases passed off into a main which communicated by two pipes, one to each side of the furnace, to the entrance of the flues at the bottom of the retorts, and were ignited by the aid of atmospheric air. These flues were constructed spirally, in order that the heat from the burning gases might permeate the materials inside of the retorts, while the exhaust gases were thrown off by chimneys at the top of the retorts. This small furnace was worked for about two months with raw coal as fuel only, and the results obtained were highly satisfactory, notwithstanding that the furnace was of so small dimensions. The iron produced was Nos. 1, 3 and 4, and that from materials that had been only 16 hours in the furnace, so great was the rapidity of the "driving" of the furnace. An examination was daily made into the interior of the furnace at the bottom of the retorts, and invariably the coal was found thoroughly coked and at a high heat, the lime completely calcined at the same temperature, and at a like temperature also were the ores. Being convinced that this plan of working a furnace was practicable, operations were immediately commenced for altering one of the ordinary furnaces at the Monkland Ironworks on the same plan, or nearly so. Mr. Ferrie, with the aid of diagrams, described this furnace, and also another modification of a self-acting coke furnace. The throat of this furnace was contracted in diameter, whilst of a proportionally increased vertical length, so as to form a single retort, which was heated by burning gases surrounding it. He proposed to introduce a portion only of the coal, or, it might be, of coke, into the central retort along with the ores and flux. The retorts at the outside of the lining were to receive the remainder of the coal, which became coked in descending the retorts, which were heated by burning gases in flues surrounding them. These retorts were continued downward, separately, from the central part of the furnace nearly to the hearth, so as to keep their contents distinct and to insure the coke formed in them being interposed at the hearth between the ores or metal and the blast jets. This plan of furnace was intended to secure that the coke should be at all times between the blast and the ores, and the writer anticipated from such an arrangement an increase in the production of carbonic oxide, a regularity in the smelting process, and a saving of fuel. He had not, however, had an opportunity of putting such a furnace in practice, but he was in the mean-

time altering a furnace with the view of making the experiment.—*Bulletin of the American Iron and Steel Association.*

THE PENNSYLVANIA STEEL WORKS AT HARRISBURG.—We collate the following interesting facts and figures from the correspondence of the Philadelphia "Press:"

The Bessemer Steel Works, established 3 years since, a few miles east of Harrisburg, are in successful operation, and their business is constantly increasing. The president is Samuel M. Felton, long and favorably known from his able connection with the Phil., Wil. & Baltimore R.; and the secretary, Chas. S. Hinchman, Esq.; and Robt. H. Lamborn, treasurer. The steel works are now turning out over 1,000 tons of steel rails per month, and during the balance of the year they expect to make 15,000 tons per month, and next year 25,000. This is the first mill constructed in America especially for this branch of manufactures. Nine hundred thousand dollars are invested for machinery alone, so that they are enabled to make heavier shafting than any other establishment in our country. Their new hammer, having a 35.000 pounds weight, cost, with its appointments, $92,000, and is the largest in the United States. The anvil block of this hammer weighs 150 tons, of cast-iron, and rests upon an immense structure of solid piling, reaching to the rock, set in and under the earth.

All the rails made by this Company pass beneath this ponderous rule, which by means of relays of skilled laborers is kept in operation night and day. The high quality of rail secured by its use is already recognized by the best engineers of the country. It was through the urgent advice of J. Edgar Thomson, president of the Pennsylvania Central, that it was erected. The use of smaller hammers, although producing a rail such as is usually placed upon the market, was not capable of satisfying the fastidious officers of that Company. New machinery for still higher perfection is already projected. This expense of $92,000 is, therefore, solely to increase the toughness and improve the quality of the rail.

The greater part of their work is done by machinery, with a hydraulic apparatus, by which the ordinary labor of 200 men can be accomplished by a single hand. They own 100 acres, which is traversed by the Pennsylvania Central Railroad, and quite a settlement has sprung up in that vicinity.

Some idea of the extent of these works, and capital employed in them, may be gained when it is known that they turn out $100,000 worth of steel rails per month. They furnish rails not only to the Pennsylvania Central, but to nearly all other roads throughout the United States. Col. J. G. Stephens, resident engineer, expresses the opinion that while iron rails wear out in 8 years, steel rails will outlast 17 iron rails. The labor is of an exceedingly intelligent class, as most of the work is done by machinery, and the workmen are required to perform very delicate chemical operations. A skilful chemist is continually employed testing the products of the work and the materials used in the manufacture of the rails and forgings, that they may be kept uniform and up to the highest standard of excellence. The manager, J. B. Pearce, worked for more than two years in various Continental and English steel works before connecting himself with this establishment. He is a graduate of Yale College.—*Chicago Railway Review.*

THE French iron trade is feeling more and more the effects of the war. In the Champagne district there is still a certain amount of business doing, but in the Moselle group matters have changed greatly for the worse. Thus some of the Longwy ironmasters have decided on blowing out their furnaces; at Stiring the forges and furnaces are stopped; and at Ars a furnace has also been stopped. The mineral workings of the Moselle are, it may be added, pretty well deserted. The French Government has given out an order for a large quantity of bullets and cannon balls to Messrs. Petin, Gaudot & Co.; the order to be executed with the utmost possible dispatch. Fresh orders for armor-plates are also spoken of. The imports of iron minerals into France in the first five months of this year amounted to 228,905 tons, of which 52,117 tons came from Belgium, 46,783 tons from the German Association, 41,580 tons from Spain, 70,243 tons from Algeria, etc. The Belgian iron trade is also beginning to suffer more and more from the war, scarcely any fresh orders having come to hand. The Luxemburg ironmasters propose, however, to make efforts to keep their blast furnaces going; the construction of some new works at Esch will also be continued. Official statistics just issued show that the export of rails from Belgium in the first five months of this year was 50,617 tons, against 41,895 tons in the corresponding period of 1869, and 27,597 tons in the corresponding period of 1868. The Belgian coal trade still displays considerable activity; thus orders have been received from Dutch undertakings which formerly used Prussian coal. The Eastern of France Railway Company, which has for some time received a large tonnage of coal from Saarbruck, is also about to use increased quantities of Belgian coal.

THE last two blast-furnaces built by the Ferry Hill Iron Company, Cleveland district, England, are 103½ ft. high, 27½ ft. at the bosh, and 8 ft. at the hearth. The average make of each is 550 tons weekly. The consumption of coke is 16 cwt. per ton of iron made, and 9¼ cwt. of limestone per ton of iron when forge iron is produced. The blast is supplied by six tuyeres to each. A cast iron pipe is carried around each surface, from which smaller pipes branch off at equal distances to the tuyeres. These pipes are covered bya non-conducting composition, but wrought-iron pipes are being fixed in place of these, lined with fire-brick inside 4 in. in thickness. The furnaces are plated outside, and closed at the top on the cup and cone principle. The blowing-engine for the two furnaces has a 67-inch steam-cylinder, 130-inch blowing-cylinder, 10½-foot stroke. The stoves used are those invented by Mr. Thomas, and heat the blast to 1,400°. Four stoves are required for each furnace. Each stove has two rows of pipes; there are 9 double pipes in each row, 11 ft. in length; the pipe is of the flat form, the two passages in each being 13 in. by 4 in. inside, divided by a partition 1 in. thick, the whole of the metal being of that thickness, which renders them much lighter than the old form of pipes. The new stoves are calculated to last for 20 years and upward. The cost of one stove is about £170, or for four to supply one blast-furnace the cost will be £680. The blast enters at one side of a row of pipes, and must pass through 9 double pipes before it makes its exit at the other side. The advantages claimed by Mr. Thomas are, durability,

owing to the great length of heating surface, uniformity of temperature, and lightness of cost. It has been ascertained in practice at these works that no advantage is gained by heating the blast above 1,000 deg. temperature; no increase of make was obtained by raising the temperature from 1,000 deg. to 1,200 deg., and it is considered a further increase to 1,400 deg. would have a similar result.—*Bulletin of the American Iron and Steel Association.*

MM. Girard and Poulain have discovered a mode of freeing iron from its most mischievous impurities, which looks very promising, and deserves the attention of iron manufacturers. The first step in the process is the formation of an alloy of iron with one of the alkaline metals, it may be either sodium or potassium. This is done by forcing the vapor of one of the latter metals into a mass of molten iron. It is unnecessary to say that this part of the process is expensive, and is hardly such as could be carried out on a manufacturing scale, but the inventors profess to be able to bring about the same result in a cheaper and easier way. They say that if the coal or coke used to reduce the iron be saturated with a solution of carbonate of soda and dried before it goes into the furnace, or if common salt be employed with the fluxing materials, metallic sodium enters into combination with the iron. It may be so; but at present, so far as we know, there is only the assertion of the inventors for the fact.

An alloy of iron with sodium or potassium, when made by the first-mentioned process, is said to be very hard, but nevertheless malleable, and can be forged and welded. Either alloy oxidizes quickly in air or water, and when a current of moist air or moist carbonic oxide is sent through while it is maintained in a state of fusion, as in a Bessemer's converter, the alloy is decomposed and the alkaline metal is said to combine with any metalloids, as silicium, sulphur, or phosphorus, and in this way these latter are removed from their mixture with the iron. The final result of the operation is therefore a pure iron, but under some circumstances not defined in the paper we quote from, steel is said to be produced. This is the third process we now have for refining iron by the aid of soda salts. Which is the best of the three we must leave manufacturers to determine

Incidentally, the authors mention a curious alloy of sodium and potassium. This is composed of 4 parts of the latter with $2\frac{1}{2}$ parts of the former; and it has exactly the appearance and consistency of mercury, remaining liquid at the ordinary temperature of the air.

Taking the Dross from Furnaces.—The invention of Mr. G. d'Adelsward, Paris, consists, first, of a cast-iron cistern, divided into two compartments by partition—the cistern is constantly kept full of water; second, of two hydraulic presses or other lifting apparatus, each having a plate or platform. These plates are intended to carry small wagons, which remain immersed to receive the dross. The presses work alternately, so that there is always one wagon receiving dross. They may be worked by a natural water-pressure, when obtainable, or by an arrangement of accumulators. The presses are only mentioned here as a means of lifting the wagons, and they might be replaced by cranes or by any suitable lifting apparatus.—*Mining Journal.*

RAILWAY NOTES.

Grades and Curves.—The modern locomotive makes it possible to use much heavier grades and sharper curves than were formerly thought admissible. In the report of Mr. John Fanderson, Chief Engineer of the Portland and Ogdensburg Railway, he refers to the heavy character of the work shown by the surveys, and says:

But nowhere will there be required so steep a grade line or such heavy work, by from one-third to one-half, as on railroads now and for many years in successful operation in this country. In point of fact, while more than double the rise per mile of the maximum grade planes exacted by this pass have been overcome by locomotive engines in the regular traffic of railroads across the Alleghanies, there have been in New York and in New England single cuts which involved more excavation than would be required by the 3 miles under consideration, and single miles of greater cost of construction than the aggregate of these three. As instances, I may adduce an earth cut on the Sullivan road in New Hampshire of 240,000 cubic yds.; another of 235,000 cubic yds., 55,000 of which was rock, on the Midland road in New York; and a through rock cut of 111,000 cubic yards on the Montclair road in New Jersey. While as to gradients, although many instances might be cited, I think the following extract from a letter of Mr. H. D. Whitcomb, Chief Engineer and General Superintendent of the Chesapeake and Ohio Railroad, will be deemed sufficient to sustain my position, and to show what has been accomplished in the practice of traversing mountains by railroads. Mr. Whitcomb, under date of Dec. 24, 1868, says, in relation to a line of railroad crossing the Blue Ridge:

"The track was $5\frac{1}{2}$ miles long, maximum (grade) on tangent 278 per mile, on curves 250 ft. per mile; minimum radius (of curves) 232 ft. Some of these curves were on trestles 40 ft. high. We used this track from 1854 to 1857 without an accident, except in a trial trip, and that not serious, and not the fault of the road, but of the brakes on the car.

"Since that track was made we have made another at a point further west, to avoid some very heavy work which we did not have money enough to complete. We have been working that for 11 years without an accident. The maximum grade is 308 ft. on curves of 500 ft. radius. The minimum radius is 400 ft. on 252 ft. grade. Our ordinary engines traverse this tract with the assistance of the engines formerly used over the Blue Ridge track.

"We are now constructing a third track still west of this point and on the grade ascending the Alleghany. We have on this grade a tunnel 3,600 ft. long, and at the eastern end of it an embankment 185 ft. deep. To avoid this temporarily, we are now constructing a grade of about 280 ft. per mile on curves of 600 ft. radius. * * *

"The usual load drawn over the 308 ft. grade by these Baldwin engines is 3 loaded freight cars, a gross weight of say 50 tons; but they will draw 4 cars. The speed we adopt is from 5 to 6 miles per hour. We have in our mountains in the winter

both snow and sleet, the latter as bad as you ever have it."—*American Railway Times.*

Locomotive Statistics.—The annual report of Mr. J. A. Jackman, Superintendent of Machinery for the Chicago and Alton Railway, contains a few interesting facts. The Company has 108 engines, of which 84 burn coal, and 24 burn wood. The average number of miles run to a ton of coal was 37, average miles to a cord of wood 42. Wood costs $6 per cord, and coal $2 92 per ton on the tenders. The average cost for repairs for a mile run is 9.20 cents, and it costs 2 cents per mile run more to repair the coal burners than it does the wood burners. Of the 2,543,397 miles run by all engines, 1,438,506 were run by freight engines, 584,519 by passenger engines. The following table gives the full cost of locomotive service for the year :

Total cost of repairs		$235,038 57
Wages of engineers and firemen....		178,845 91
Cost of fuel......................		260,256 26
Cost of oil and waste..............		26,702 89
Cost of cleaning engines...........		37,360 87
Cost per mile run for repairs..	$9 20	
For engineers and firemen....	7 00	
For fuel	10 23	
For oil and waste............	1 04	
For cleaning engines	1 47	
Total cost per mile run ...	——	28 91

against 31.41 cents the previous year. Included in the cost of repairs during the past year is one engine entirely rebuilt. Most of the engines were built by the Schenectady Works and the Rogers Works ; although a few were made by others, including four or five built at the Company's shops. The prevailing size of cylinders is 16×24 ; drivers 60 to 68 in., 4 to an engine. Mr. Jackman says : The intention has been, and still is, not to allow the motive power to depreciate ; and to fully compensate for any depreciation that might by any possibility have occurred, new works, in the shape of new boilers, new fire-boxes, new wheels and axles, new tyres, new parallel rods, new tanks and tenders, and all other parts of depreciative machinery, have been added in sufficient quantities to cover that portion of insensible depreciation which, to a greater or less extent, is common to all operative machinery, and which cannot always be compensated for by the general repairs, however thorough these repairs may be.—*American Railway Times.*

Mining Engines.—Messrs. M. Baird & Co., of the Baldwin Locomotive Works, Philadelphia, have built during the present year a number of small locomotives for use in mines, hauling away cinder, etc. The engines referred to are miniature locomotives, adapted to narrow gauges of 2½, 3, or 3½ ft. The Thomas Iron Works, Hokendauqua, the Lehigh Crane Iron Works, Catasaqua, and the Glendon Iron Works, Easton, are each now working 2 of these machines for hauling away cinder from their furnaces. At the former establishment the 2 engines do the work which formerly required 30 mules. The economy of their use is therefore manifest. For out of door work, the little engines are built with outside cylinders 9 in. in diameter and 12 in. stroke; the driving wheels are 30 in. in diameter. For mining purposes the cylinders are placed inside, the extreme width is reduced to about 5 ft., and the extreme height to 5 ft. 4 in. When running in the heading of a mine, it is intended that coke shall be used as a fuel, so that little or no smoke or gas will be produced. These engines, in complete working order, with tank of water on boiler, and a man on the footboard, will weigh only from 6 to 8 gross tons.—*Miner's Journal.*

We have received the following description of an Elastic Railway Rail from Mr. F. A. Meredith, Mount Airy, Carroll County, Md., the inventor and patentee :

The improvement consists of Rail, Base, and Cap or Head. The base rail is in the shape of a U, with the prongs upward, and the base at the bottom to rest on the ties. This forms a solid rail with a groove in it. This groove is set with spiral springs, side by side. These springs have 3 rounds, or more if necessary, and any power can be had from them that is wanted for rolling freight. The cap of steel has a tongue to its head or cap, neatly fitted into the groove of the base rail on the spring. This rail is put down on the spring tight enough to take the less motion off the spring. The cap is held to its place by bolts put through the groove and tongue of the cap. The holes in base fit the bolts neatly, and the holes in the tongue are larger than the bolts, so as to allow the springs to work, and for expansion and contraction. The springs are not allowed more than an eighth of an inch play, when the engine is pounding the track. The joints of this rail are broken by each other ; the ends of the cap rail have a tongue and groove fitting together. So when the engine comes near the end of the rail it brings the other rail down so as to form a smooth surface—that it will appear as a solid rail. Now if the cap should break, it cannot get out of place ; and, if it should, the engine would run on the base, which is stationary.

When the rail wants replacing, all to be done is to take the bolts out which hold the cap and the cap set in. This track is not likely to break an engine tyre, as it is not solid enough.

When the engine is in a slow walk the track will be a solid rail, but at full speed it will give sufficiently to take the heavy pounding from the top, thus saving both rail and machinery.

Broken Axles.—In the late annual report of L. J. Fleming, Chief Engineer and Superintendent of the Mobile and Ohio Railroad, after saying that accidents from defects in machinery, except from broken axles, had diminished, the following remarks on the causes and prevention of broken axles are given :

"The accidents from broken axles, principally under tenders, may be ascribed to two causes—the granulating effect of the heavy, rigid rail when laminated, and the very bad quality of metal of which axles are frequently made. Manufacturers generally believe there is no method of testing the quality without breaking the axle, and when accidents occur, that they will be attributed to the effects of granulation from vibration and impact ; and that there is no means of tracing them to the bad metal of which they are made. For some time past all new axles have been ordered of sufficient length to take a fracture from each end, and one or two of each lot has also been broken in the centre. The result of these tests has been to return to the makers ¾ of those ordered within the past year. In future orders, the names of the makers will be required on each one, and the pro-

per credit or blame will be given in the annual reports. The person who manufactures a bad axle, on which the lives of so many passengers depend, whether it is done intentionally or from the want of a proper knowledge of making it, is as culpable as the person who places an obstruction on the track to throw off the trains."—*Engineering and Mining Journal.*

Peruvian Railways.—Peru is constructing three great railroads to connect her coast with the countries east of the Andes. The one from the coast to Arequipa, and across the Andes to Puno, and thence to Lake Titicaca, on the dividing line between Peru and Bolivia, is progressing rapidly. Forty miles have been finished between Arequipa and the coast, and traversed by powerful engines with construction trains. There are 6,000 laborers at work on the road. The difficulties of the mountainous ground are tremendous, but they have been hitherto triumphantly overcome. Many of the huge cuttings and embankments have called out the highest kind of engineering skill. Within 6 months, the ancient city of Arequipa, founded by Pizarro, away up in the vale of the Andes, will be in close communication with the coast. The region around Arequipa is rich in silver and copper mines, and produces cotton, wool, sugar, and nitre, the exports of which have been comparatively inconsiderable for want of cheap transport. This the railroad will give, and will inspire new life into the commercial and social relations of those productive but hitherto little known elevated valleys of the Andes.—*Commercial Advertiser.*

In a letter to the "Times" Sir Joseph Whitworth makes a suggestion relative to the construction of railway axles, which is deserving of attention by the engineers of railways. He proposes that a hole should be drilled through the centre of the axle, throughout its length, thus opening up to inspection and examination that part of the material which, in the case of ordinary manufacture, is most subject to unsoundness. The hole should be about 1 in. in diameter, and, with suitable mechanical arrangements, might be drilled at an average cost of about 1s. 6d. per axle. With the outside turned and the inside thus exposed to view, a serious flaw in an axle, which is only about 4½ in. in diameter, could hardly escape discovery. The plan, he says, would also diminish the tendency of the axle to get heated, and by removing the material near the neutral axis, would, under the circumstances, reduce the internal strains, and render the axle safer.—*Railway News.*

Bessemer Steel Rails in France.—The use of Bessemer steel rails is extending daily in France. MM. Schneider & Co., of Creusot, have contracted to supply the Paris, Lyons, and Mediterranean Railway Company with 20,000,000 tons at £10 per ton at the works. They have also contracted to supply the Orleans Railway Company with 2,000 tons at £10 6s. per ton, to be delivered at Saincaize.

Among the noticeable inventions which interest railway managers is one of Mr. Wm. S. G. Baker's, of Baltimore. It is essentially a mode of making the cylinder steam-chest and bed-plate of locomotives in one piece.

The advantage of this mode of construction is in reducing the weight of the engine and lessening the number of steam joints.

The steam-chest, moreover, is, by this arrangement, formed within the bed-plate, and being covered by the smoke-box, there is less loss of heat from radiation than in the common plan.

Some engines have already been built upon this plan.

The Hannibal "Courier" describes an invention of Mr. Stephen M. Richards, a superintendent of the Pullman Palace Car Lines west of the Mississippi, for the improvement of railway tracks. It consists in supporting the rails in spring attachments upon rubber bearings 1½ in. in thickness, set in sockets upon the cross ties by a patent fastener. The rail fastenings, too, are Mr. Richards' invention, and are so formed that a rail can be removed in an instant by removing a small screw. The Hannibal and St. Joseph Railway are preparing to lay a few miles of track with this improvement, and Mr. Richards has visited Chicago, to lay his invention before several roads.

ORDNANCE AND NAVAL NOTES.

The Whitworth Gun in France.—A document has come into our hands which indirectly throws considerable light upon the present condition of the field artillery of the French army. It will be remembered that Sir Joseph Whitworth sent to the last Paris Exhibition two specimens of his steel field-pieces, the one a 10-pounder and the other a 3-pounder. These guns, having attracted the notice of the Emperor, were sent by his desire in the first instance to Versailles, and afterwards to the camp at Chalons, for exhaustive experiment, under the direction of the Commission Permanente d'Experiences, and it is their report which we have now before us, dated so recently as last year. It is a most valuable document as a record of the performance of English field guns in the French camp, but its chief interest at the present moment lies in the undoubted evidence which it affords of the great inferiority of the field guns, made of bronze, with which the French artillery is equipped in the war with Prussia, at least as compared with English steel guns. This evidence is supplied by a series of tables near the end of the report, in which the performances of these latter guns are compared with those of the "*canon de quatre de campagne*," as regards range, lowness of trajectory, retention of velocity at long distances, and accuracy. In all these particulars the French bronze gun was much inferior to both of the steel guns, and in some respects is so inferior as to bear no reasonable comparison with them. Even at 5 deg. of elevation, the range of the 3-pounder exceeds that of the French 10-pounder by 290 metres, while the English 10-pounder exceeds the other by 440 metres. But as the range increases, the inferiority of the French becomes much more marked. Thus, at 10 deg. the French gun ranges 2,350 metres, the English 3-pounder 3,120, and the English 10-pounder 3,320. At 20 deg. the ranges are 3,480, 5,000 and 5,490 metres respectively; and at 30 deg., while the range of the French gun is but 4,100 metres, the English 3-pounder has a range of 6,100, and the 10-pounder 6,890 metres. These inferior ranges of the French gun are associated, as they must be, with correspondingly high flights

or trajectories, rendering the aim of the artilleryman very uncertain in the field, where distances have to be judged hastily and by the eye alone In ranging 2,000 metres the French shell rose to a height of 83 metres, while the highest point of the trajectory of the 3-pounder was 54 metres, and of the 10-pounder only 51 metres. At 3,000 yards' range the *maximum* ordinate of the trajectory of the last-named gun was 130 metres, that of the 3-pounder 137, and that of the French gun 253 metres! Those who understand the relation between a low trajectory and good aim in the field will discern the immense disadvantage of the French gun in this comparison. Not less remarkable is its want of *conservation de la vitesse*, or the quality of keeping up the power to hit hard throughout its flight. The initial velocities of the projectiles of all three guns were nearly alike, varying between 331 and 361 metres per second; but after travelling 1,000 yards the velocity of the French projectile fell to 247 metres, that of the steel 3-pounder being still 302, and that of the 10-pounder 311 metres. At 2,000 yards the velocities were 194, 276, and 282 metres; and at 3,000 yards 166, 252, and 264 metres. As the penetrating effect of a shell depends upon its velocity, it is easy to see how inferior the French arm must be in this respect likewise. Its inferior accuracy is also very remarkable, especially at long ranges, but we have not space to record all the figures. Those already given are taken without alteration from the official report. It is only necessary to add that bronze is of less than half the strength of good steel, or of Whitworth metal, and that much of the inferiority of the French gun is attributable to its use, it being quite impossible to fire the full charges of powder and length of projectile from a bronze gun of given bore without speedily destroying it.—*Times.*

An experiment was made recently at the Easter-road Barracks by the Edinburgh Militia Artillery, which is noteworthy as probably the first time that heavy guns of position have been handled with ease and rapidity without horses, bullocks, or elephants. By means of Thomson's road steamer two guns of 50 cwt. were moved at 6 miles an hour, and wheeled while moving at that rate in a space 8 yards in breadth. They were placed in position with a precision and rapidity that could scarcely be attained by any other means with guns of equal weight. This, it may be remarked, is the first time that Thomson's road steamers have been actually applied to heavy artillery. It is extremely probable that they will be largely used in future military operations. We understand that a number of these engines are being made for the British and Indian Governments, and that they will in future probably be in constant use by all civilized armies. Friday's work will, therefore, be quoted in future as the commencement of a new and important application of steam to warlike purposes. We understand that Mr. Thomson has offered the loan of engines to transport the guns in charge of our regiment of Militia Artillery to Dalkeith. The value of the appliance can be judged when we state that these heavy guns could be brought into action, at Dalkeith, which is six miles from Edinburgh, within an hour and a half after the order was received from Edinburgh.—*Engineer.*

The 35-Ton Gun.—Our Woolwich correspondent states that the large gun now in course of manufacture at the Royal Gun Factories, Woolwich, is expected to prove the most powerful piece of ordnance ever produced, and to settle definitely the long and hitherto even contest between guns and armor. It will weigh 35 tons, and will hurl a projectile of 550 lbs. with a charge of 100 lbs. of powder, thereby imparting an initial velocity which will enable it to pierce an armor plate of iron 15 in. in thickness, beyond which no ship meant to float can surely go. The barrel is of steel, strengthened at the breech by a strong iron jacket, and the calibre of the bore is about 11½ in., but this point has not been definitely settled. Indeed, the gun is at present altogether experimental, but if it answers expectation it is easy to guess what a formidable foe it will be to the iron-clads.—*Pall Mall Gazette.*

On the subject of the fortifications of Paris, the "Journal Officiel" says:—"One newspaper still dares to put questions respecting the armament and the fortifications of Paris, although it is an act of treason to speak thus in the presence of the enemy. Insinuations like these make it necessary to reply, in spite of the evident danger that there is in doing so. All the armament of Paris is in Paris itself. More than 600 cannon are already on the ramparts of those forts which will be first menaced; others are being placed in position continuously day and night with the greatest activity. On Saturday 7,500 workmen were employed in cutting the roads that lead into Paris. These cuttings have all been made, and there now only remain the details necessary to complete the preparations for closing the draw-bridges. Thousands of workmen are occupied outside the city upon the earth-works, which will complete the *ensemble* of the permanent forts. These are the details and the figures which we are obliged to give in reply to perfidious and erroneous insinuations, and in order to re-establish the confidence of good citizens. If such questions are renewed, it is before the Council of War that their authors will have to answer for their conduct. They will undergo all the penalties of the law, for these are times when, less than ever, it can be permitted to slumber."

The Prussians were unanimous in declaring the Chassepot inferior to their own Dreyse. "It certainly has the wider range," they said, "and sometimes kills a man at the most unexpected distances; but then you cannot take aim at above 900 paces, and what is the use of blazing away unless you have a fair chance of doing execution? Besides, the immense range of the gun interferes also with your taking aim at short distances, and the large quantity of powder in the cartridge makes it impossible for any one to stand the recoil. You cannot properly handle a gun that boxes your ears. We have frequently seen men pressing their guns against their breasts and thighs when firing. If the chassepot could be pointed and discharged by a machine, it would be a terrible weapon indeed." The mitrailleuse is voted an exceedingly unpleasant thing by the Prussian soldiers, "but then, you see,"—they will add qualifyingly—"they always fire as straight as you can go. The moment you turn a little to the right or to the left you are safe. It was always much easier for us to evade the balls than for the French to alter the aim of the mitrailleuses."—*Prussian Correspondent of the Times.*

A FINE gun has arrived at the Gun Wharf, Devonport, from Woolwich, for the iron-clad ram "Hotspur." It is a 12-in. muzzle-loading rifled gun of 25 tons (Fraser's construction), and carries a 600 lbs. shell, with a battering charge of 67 lbs., and a bursting charge of 35 lbs. of powder. It is rifled with 9 grooves, and its cost exceeds £2,000. This gun of Fraser's construction is an improvement on the original Woolwich gun ; it has only 2 coils, which, together with the trunnion, are forged on to the tube, and they are so incorporated that the gun may be fairly described as being in 2 pieces only—the tube and the united coils and trunnion. With the original construction there were in the 8-in. 9-ton guns 4 rifled grooves and 5 coils, which latter entailed a vast amount of labor and expense in construction, besides which it was found that these coils, being so numerous, were subject on heavy firing to loosen and shift, which was especially the case with the 12-pounder field gun made on the same principle ; but with the improved Fraser gun this cannot occur.

ABOUT 300 men (including more than 100 from Woolwich alone) have been enlisted and passed the medical examination at Woolwich for the Army Service Corps since the order to enlist for this corps was issued. 500 men are to be added to the corps, and three additional companies will be formed in the transport branch and two in the supply. Many recruits have also joined for the Royal Artillery and other corps. Though there is no bounty given, young men are offering themselves in great abundance, the reduction in the standard having opened the ranks to many who have been precluded only by their insufficient stature from joining the army long since. Specimens of the French chassepot and the Prussian needle-gun are exhibited to the public in the Rotunda at the Royal Military Repository, Woolwich.

WE understand that the Lords of the Admiralty have decided upon making some valuable additions to the iron-clad navy, and have called upon the leading shipbuilding firms in the United Kingdom to tender for the construction of 4 vessels of the "Scourge" class. It is also intended, we believe, to build 2 other ships similar to the "Cerberus."—We have reason to believe that even if the war now being waged on the Continent has an early termination, the "Flying Squadron," which was to have left our shores in October, will not now be despatched. Public confidence has received a shock, and cannot be easily restored.—In a trial of sailing last week the "Repulse" showed that she had the heels of the whole Coastguard Squadron, beating the "Achilles," which has obtained a celebrity as having beaten the fastest iron-clad under sail of the former Channel Squadron.—*Army and Navy Gazette.*

A NEW method of converting the Enfield muzzle-loading rifle into a breech-loader was tried in the Royal Arsenal, Woolwich, on Tuesday evening. It is the invention of Mr. T. Restell, of Birmingham. The breech arrangement consists of a steel block, which is moved horizontally to the right by the cocking of the rifle, and when the cartridge is inserted the pull of the trigger closes the breech and fires the rifle simultaneously. The chief merits of the invention are rapidity, simplicity, and cheapness. In the hands of a rifleman who had not seen the weapon before, it made on Tuesday 27 rounds in 2 min., with a score of 68 points. The Enfield, it is stated, can be converted into a breech-loader on this principle at a cost of 5s. each.

NEWS has been received of the expedition of Sir Samuel Baker. On June 13, he was at Tewfikiyeb, lat. 9.26 N.

ENGINEERING STRUCTURES.

THE WORK ON THE BROOKLYN PIER OF THE EAST RIVER BRIDGE.—The lower edge of the great caisson is 29 ft. below high water, and is steadily going down. The fourth course of masonry is being laid on the top. The water shafts have been lengthened upwards, and the air shafts are to be treated likewise at once.

An interesting experiment was performed recently under the caisson.

It must be remembered that the water shafts through which the excavated material is raised, extend downward about 6 in. lower than the edge of the caisson. A pit is kept about each shaft, into which the workmen below dump from barrows the earth to be raised through the shaft by the dredge.

A large boulder was recently found at the bottom of one of the pits. It became necessary to remove it with as little delay as possible. The water shaft was fitted with a tight cap of boiler-plate iron (which the foresight of the engineer had provided in the original plan), and an air connection was made between the caisson-chamber and the upper portion of the water shaft.

The water of the shaft, which always stands at the height of the water in the river, ran quietly down and away under the edge of the structure.

To sink the pit to sufficient depth to remove the boulder the water had to be got rid of. So pumps were sent down, and the pit, beginning at the bottom of the river, was sunk 12 or 15 ft. further, with the same means and with as few hindrances as it would have been in the open air. The stoneworkers followed the pumps, split the boulder to fragments with wedges, left the pit to fill with water, when the cap on top being removed the water filled the shaft to its wonted level, and the ordinary routine was again pursued.

This operation at one shaft did not interfere with the work at the other, about 20 yards distant.

ELECTRO-MAGNETIC ENGINES AGAIN.—The French journal "Le Nouveau Monde," published in New York, contains an account of the operation of a new electro-magnetic motor, invented by Mr. E. Prevost, which we would not notice if our criticism did not with it carry an instructive lesson. The account says :—

"It has been believed hitherto, that the power produced depended on the number of elements used in the electric battery. This Mr. Prevost denies. In the same way as one single spark is sufficient to ignite as well a ton as a grain of gunpowder, so Mr. Prevost proves by facts that with two elements of Bunson, 8 in. high by 6 in. in diameter, electro magnets may be charged developing a power of 8,000 lbs., whatever be the difference of the force, size, or number of the electro-magnets submitted to the influence of the battery.

We have seen with our own eyes that the number of the electro-magnets was increased without the least loss of force in any of them, and that the operator then removed several of them without the least increase in the attractive force of those remaining.'

Then the account goes on with the stereotyped and erroneous statement that the expense is very small. The inventor is, of course, "ready to satisfy the incredulous public, by experiments on a large scale, that the invention possesses great practical advantages," etc.

This is the same old story renewed. These experiments on a large scale have been made over and over again, and it is well-known by those familiar with the subject, that the "incredulous public" has been thoroughly satisfied, by that very means, that such inventions possess no practical advantages whatsoever.

The assertion made by the editor on the authority of Mr. Prevost, that the number of electro-magnets may be increased without loss for each individual one, proves only ignorance of the laws of electric currents. Ohm discovered the law of relation between the batteries and the wires discharging the currents, developed by the oxidation of the zinc and decomposition of the fluids in the battery. This law is called the law of Ohm; and, in order not to trouble our readers with the formulæ, we will only remark that its chief result is, that the battery works to its utmost capacity and utmost result when the resistance which the discharging wire offers to the current is equal to the resistance which the battery itself offers to the passage of the same current.

Metals are much better conductors than fluids. surpassing them several million times; copper conducts the current 20,000,000 better than the best solutions in the battery, to which the resistance of the porous cups has to be added; consequently a Bunson battery of two cups is able to discharge its current through many miles of copper wire, without experiencing a resistance greater than the current has to overcome in the battery itself; how many miles may be easily calculated from the dimensions of the battery, thickness of wire, etc.

As long as the length of the wire is below this the whole power of the battery is discharged, and no change in the currents of the wire and its effects on electro-magnets can be perceived, though we increase the length of the wire and charge, say 4, 8, or even 20, or 50 electro-magnets; but as soon as we increase the number of magnets so that the length of the wire surrounding them surpasses the limit at which the resistance it offers to the current is equal to the resistance offered by the battery, the whole power of the battery can no longer be discharged, and the power of the individual magnets will commence to decrease. These laws are of the utmost importance to the telegrapher, who has to overcome great resistances, produced by passing electric currents through long distances and over very long wires. In fact, these laws were discovered in the use of the electric telegraph; and every telegraphic electrician can tell this inventor that he is generally mistaken in his denial of the demonstrated fact that the "power produced depends on the number of elements used in the electric battery."

His comparison of a "spark igniting a ton as well as a grain of gunpowder" is quite out of place. Most inventors of electro-magnetic machines are at the present day in a much denser fog than ever were those who attemped to improve the steam-engine. They are, in regard to electric currents, on the same level as those are in regard to a steam pressure who ignore the law of Mariotte, the atmospheric pressure, and the theory of the crank or eccentric.

We recommend to all those who venture on this field a thorough study of the law of Ohm in its special applications to electro-magnetism. The most valuable work for them to study is Dub's "Electro-Magnetismus" (Berlin, 1861); it will cure them of their delusions. — *Manufacturer and Builder.*

Atmospheric Telegraph—Successful Test of a Novel Process in England.—Herapath's "Railway Journal" of July 16th, gives a description of experiments on the system of telegraphing invented by Signor Guattari, which substitutes atmospheric air compressed in a reservoir for the electric battery, and tubes filled with air for conducting wires. The apparatus consists of a reservoir of compressed atmospheric air, regulated so as to provide the requisite force of velocity with which signals are to be sent through tubes from one place to another. Vulcanized india-rubber tubing about half an inch diameter, said to be a mile in length, coiled round a drum, was attached to the reservoir at one end, and to another apparatus at the other end of the tube to receive and print the signals as given from the reservoir or battery end of the tube. The tube (of any suitable metal) is provided with a movable vent, by which more or less force can be given to the current of air by which the signal writing or printing mechanism is actuated. The signals are given by pressing a certain number of times on a piston by which pulsations are given to the air in the pipe or tube and transmitted through a valve to a lever connecting with the writing apparatus, marking on a moving strip of white paper the impulses given at the reservoir end of the tube. As the signals are given at one end of the tube, they are immediately printed at the other end in a similar manner to Morse's instrument.

An indicator shows the force of the current of air passing through the transmitting tube or pipe, as the case may be; and similar indicators are placed near each end of the communication. Several messages were sent through the tubes and printed at the other end. A long conversation ensued as to the velocity of the messages and the capability of the apparatus for various purposes. It was inquired on the part of the post office authorities how many words could be sent in a minute by the atmospheric telegraph; it was stated from 20 to 24 words could be sent by the present apparatus, the greater portion of which had been made by the inventor, and therefore its working was capable of being greatly facilitated and improved by a more skilful workman, so that he was confident that at least quite as many words could be telegraphed by the Guattari system as by the electric telegraph.

A naval apparatus was also worked showing how signals could be given to five different departments in a war steamer—to the engine room, the powder magazine, the steering, etc., and that

orders had been given for its adoption in the Italian navy.

The mode of telegraphing to one or more stations without the aid of the transmitting machine, or the necessity of the sender being confined to any one point, was shown.

Signor Guattari stated that his system was more economical and simple to construct and work than the electric telegraph; that it was free from atmospheric influences which so materially disturbed the electric telegraph during storms, and would not be so subject to accidents. It was calculated that the machinery and instruments could be provided and maintained at half the cost of those required for the electric system. There were no batteries to be renewed at considerable expense; and he maintained that any result attainable in the electric was equally attainable by using the Guattari system.

There seemed to be no doubt from the experiments that this system of telegraph would be effective for moderate distances for large establishments, ships, and towns, but that more extended experiments would be requisite to prove that it would be equally as efficient and certain as the electric telegraph for very long distances.

A SET of the largest pumping engines yet made have just been completed by Messrs. Gwynne and Co., of the Essex Street Works, Strand; they are to be erected in Denmark for some heavy drainage works, to reclaim 20,000 acres of land for the Nissum Fjord Company, and of the most approved construction. The manufacturers are confident that the engines and pumps will raise 40,000 gallons (178½ tons) 12 ft. high in one minute, which is nearly 50 per cent. more than contracted for. The machinery consists of a pair of engines, 4 ft. apart from centre to centre, coupled, with one pump on each side. The engines are 21 in. cylinder expansive condensing, 21 in. stroke, mahogany lagged, running at 140 revolutions (490 ft. piston speed) per minute, and consuming 3 lbs. per horse-power per hour; vacuum, 27 in. The pumps are constructed on Messrs. Gwynne & Co's. well-known centrifugal principle, and are 42 in. diameter in the pipes. The same manufacturers will shortly have completed a combined pumping engine for the Punjaub Railway, to discharge 1,000 gallons per minute 60 ft. high.—*Mechanics' Magazine.*

THE NEW CABLE BETWEEN ENGLAND AND FRANCE.—The new cable for the Submarine Telegraph Company, to be laid from Beechy Head to Cape Autifer, near Havre, a distance of about 70 miles, has been commenced at Mr. Henley's works at North Woolwich, and will soon be completed. It forms a large, massive cable, and will be one of the largest yet manufactured. The core consists of 6 insulated conductors, wormed and served in the ordinary manner; each conductor is a strand of 7 wires, weighing 107 lbs. per nautical mile, and insulated with 3 coatings of Chatterton's compound and 3 of gutta-percha to the weight of about 150 lbs. per mile. The severed core is sheathed externally with 12 No. O. B. B. galvanized iron wires, protected with 2 servings of tarred hemp and bituminous compound. The shore ends have a similar core, but are sheathed with 12 No. 0000 B. B. galvanized iron wires, protected with two servings of hemp and compound. This is the first time wire of such enormous diameter has been used for submarine cables. Land lines for this cable are being erected between London and Beechy Head, and Havre and Paris, so that the new line will be an independent one, and will tend to obviate, if not prevent, the delays which have frequently occurred in the transmission of messages between London and Paris, arising chiefly from a pressure of business. In future any breakage which may take place in the old and new lines will be quickly repaired, because, under the authority given lately, the Company will conduct repairs with their own repairing ship, instead of employing a tug, as hitherto.—*Mechanics' Magazine.*

ELECTRIC BUOY.—An electric marine buoy, the invention of M. E. Duchemin, was exhibited at Cherbourg some time since by order of the Minister to the Marine. The electricity was produced by the constantly-renewed action of the sea-water on zinc, but the inventor has since carried on a series of experiments in order to ascertain if an increase of intensity could not be obtained as in ordinary batteries, by means of certain chemical substances held in suspension around the zinc or charcoal element. The new battery resulting from the experiments consists of a porous vase fixed on a wooden buoy or floater. The vase is surrounded by a thick zinc cylinder, pierced with holes, the wire of which represents the negative pole. Within the porous vase is placed a slab of gas-retort charcoal, to which is affixed the conductor of the positive pole; the charcoal is surrounded by pieces of coke and perchlorate of iron. The vase is carefully closed, and the battery when plunged in the sea immediately gives forth large quantities of electricity. A commission consisting of M. Becquerel, General Morel, and Marshal Vaillant, has been appointed to examine this marine electric apparatus.

NEW BOOKS.

THE METALLURGY OF LEAD, INCLUDING DESILVERIZATION. By JOHN PERCY, M. D., F. R. S. London. John Murray, Albemarle street. For sale by Van Nostrand.

The continued improvement in the lead market coupled with the prosperous position of the mines of that metal in North Wales, will cause even more than usual interest to attach, at the present moment, to the exhaustive volume just completed by Dr. Percy, of the Royal School of Mines. The original intention of including the metallurgy of silver and gold, as well as that of lead, has not been carried out, and it is explained that it was found impossible to embrace the whole in one volume of convenient size. As usual with Dr. Percy's works, the subject is treated exhaustively, and as all the diagrams given are drawn to scale, the practical lead smelter is enabled not only to determine which process is best calculated to meet his requirements, but to put the process selected into actual work. The physical and chemical properties of lead are first considered; then the extraction of silver from lead, and lead smelting; and lastly, the preparations of lead compounds usually met with in the market.

With regard to the physical properties of lead, Dr. Percy tells us that it belongs to the class of

white metals, but has a decided bluish-gray tint. A freshly cut surface has a bright lustre, but it soon becomes dull from atmospheric oxidation. To the eye lead usually presents no sign of crystalline structure, though it is certain that the metal is an aggregation of crystals. Ihle observed very distinct octahedral crystals of lead in a cavity in a pig of lead from the Muldener Hütte, Freiberg; yet crystals sufficiently defined to admit of measurement by the goniometer have not been obtained. Lead is the softest metal in common use; it is very feebly elastic or sonorous, the dullness of sound being generally proportionate to the purity of the lead; and it does not cry, like tin, on being bent. Its specific gravity is about 11.38 when chiselled out of a very pure pig. Lead in a state of fine division may by mere pressure be made into a solid mass; thus, a paste of sulphate of lead and water is spread an inch thick upon a plate of zinc, and the whole is plunged into the upper part of a solution of common salt not quite saturated. After a few days the paste will be changed into a coherent soft mass of lead, which by immersion in hot water may be freed from the interposed solution of salt. Under a powerful press this mass becomes a solid plate of flexible lead, which stamped in a mould gives a sharp impression. If not strongly pressed, the mass readily oxidizes

The chemical properties of lead are very fully treated of. The atomic weight, taking the average of the various authorities which Dr. Percy quotes, is 103.5. He describes the compounds of lead and oxygen, giving some very interesting particulars of the silicates of protoxide of lead; of lead and sulphur, recording a large number of carefully made experiments by Mr. J. C. Cloud, not previously published; of lead and carbon, mentioning the efforts that from time to time have been made to substitute the direct production of the carbonate of lead or white lead for the original Dutch process generally employed; of lead and arsenic, suggesting that nickel and cobalt should act like iron upon arseniuretted lead and phosphorus remarking that experiments by Mr. Cloud confirm the statement of Berthier, that there is no reaction between phosphate and sulphide of lead at a high temperature; of lead and chlorine, stating that according to Berthier litharge partially decomposes choloride of sodium by the dry way, and melts easily with chloride of barium or calcium, producing yellow crystalline insoluble oxychloride resembling Turner's Patent Yellow, from which water separates the excess of chloride of barium or calcium mixed with baryta or lime respectively; of lead and nitrogen; and of lead and antimony, explaining that when lead alloyed with antimony is calcined (say) at a moderate red heat, with free access of atmospheric air, both metals are quickly oxidized, but the antimony in greater proportion than the lead, antimoniate of protoxide of lead being formed, so that by means of calcination lead may be practically freed from antimony; and accordingly such a process is adopted on the large scale in what is termed softening.

Referring to the alloys of lead, it is stated that the alkaline reaction of a freshly-cut surface of the alloyed lead, prepared by Vauquelin by heating oxide of lead with cream of tartar, is fallacious as an indication of the presence of potassium, since it is found that upon laying a piece of moistened red litmus paper on a freshly-cut surface of the purest as well as of common commercial lead it becomes rapidly blue. Having referred to the alloys of lead and potassium, lead and sodium, lead and copper, and lead and manganese, he proceeds to describe the ores of lead, and inserts an admirable description by Mr. Warington Smyth, of the mode of occurrence of British lead ores. The assay of lead ores is also treated of, the principles both of the dry and of the wet way being thoroughly explained. Alluding to the wet assay of lead ores. Dr. Percy remarks that several methods have been proposed for the estimation of lead by means of standard solutions; but he is not aware that any have been successfully applied in the assaying of ores of lead. They either fail in requiring too much expenditure of time, from inaccuracy of the method, from interference of substances often existing in lead ores, or from other causes. He believes that the dry method must always be resorted to as the only direct, accurate, and practical method of quantitatively estimating the silver in lead. Some of these methods have been tried in the Royal School of Mines Laboratory during several months, and have been abandoned on account of one or more of the objections specified.

The chapter on the extraction of silver from lead will be read with much interest, since it contains a complete account of the Pattinson process, and of the accidents which led to its discovery; and more especially so when it is remarked that Dr. Percy considered it desirable that there should be a permanent record from the pen of Mr. Pattinson himself, and therefore publishes a description which, with the exception of a few unimportant verbal alterations, is Mr. Pattinson's own, and which he prepared at his request for his use as lecturer on metallurgy at the Royal School of Mines. The same chapter also contains descriptions of Parkes' and other processes of desilverizing: of the decopperization of lead by zinc; of cupellation; and the refining of blicksilber.

The student being thus provided with an ample amount of preliminary information, the subject of lead smelting is dealt with, historical notices of lead smelting in Great Britain, and some useful introductory observations on lead smelting, being followed by the description of the furnaces and processes used, and results obtained by the Flintshire, Spanish, Cornish, Bleiberg, and other systems. Of the great value of Dr. Percy's work two opinions cannot exist; probably no one is better acquainted than he is with the literature of the subject and it would be scarcely possible to utilize the knowledge which his extensive study has placed him in possession of, in a more satisfactory manner than he has utilized it in the present volume. It is really a cyclopedia of lead smelting, which may be referred to with the utmost confidence, and few will require more complete information than the book will furnish them with.—*Mining Journal.*

An Elementary Course of Plane Geometry and Mensuration. By Richard Wormell, M.A., B. Sc. Second Edition revised and enlarged. F. cap. 8vo., pp. 276. London: T. Murby.

This book is the work of a reformer, not so much of geometry, as of the mode of presenting it to the young. Sciences begin in practical ap-

plications, and tend by a universal law to become more and more abstract; and the doctrine of the reforming school is, that whatever the science may have developed into, it is necessary in teaching it to go back to practical applications, and to seek for a sure foundation for abstract notions in the familiar experience of common objects. Teachers need to be incessantly reminded of this necessity. In teaching physics, or chemistry, or botany, it is perhaps admitted, though not always obeyed; but in mathematics it is generally not admitted; and when admitted it is rarely followed out to its logical consequences. Geometry, arithmetic, algebra, must alike be presented first in their applications; and then alone, in most cases, can definition and soundness be given. In most cases, we say, because where mathematical talents of a moderately high order exist, as in the generality of mathematical teachers, this necessity is not felt. And for this reason, mathematical teachers who are not also observant of mental phrases, may be slow to believe what has just been pointed out as a necessity in their art. Many of them, we suspect, have a secret sympathy with the mathematician who proposed the health of "The prime numbers, the only branch of mathematics that has not been defiled by contact with the concrete."

The aim of Mr. Wormell's book is to teach scientific geometry, the logical dependence of truths on one another being shown, and to make the teaching sound by giving familiar illustrations of all the conceptions involved, and applications of the result attained. The book is interspersed with examples, geometrical and arithmetical. Among the subjects mentioned—we turn to the index, as giving a good idea of the book—are star polygons, axis of symmetry, graduation, land-surveying, spirals and volutes, transmission of motion by cogs, etc. Considering what the aim of the writer seems to have been, the illustrations and applied part of the book have been well done. It is generally clear, moreover, and accurate in style, and is interesting. In form it is adapted for a school-book; and for certain schools it may be a success. But it fails as a scientific geometry intended to replace Euclid in three respects; want of clear statement of axioms and exhibition of the science as rigidly deductive; the avoidance of the difficulty of incommensurables; and a degree of undefinable inelegance of treatment throughout. The book is too long, and is too nearly scientific, to use as an introduction to Euclid or to any of its modern substitutes; and, though it would replace them with advantage if the mathematical education of the student were to end with the reading of this book, it is not easy to see how the student proceeding to higher mathematics could do so without previously mastering another more complete geometry. It seems to me, therefore, a successful contribution to "technical education," and a valuable and suggestive attempt, but not altogether a successful one, to teach scientific geometry on true principles. The book is well adapted for middle-class schools. It is scarcely worth while to notice minor faults, either of the printer, which are very few, or of style. But it is really to be regretted that a degree should have been defined thus: "Suppose we have a circumference sufficiently large to be divided easily into 360 equal parts, each part is called a degree." A degree is an angle, and this conception ought to be prominently brought forward.—*Nature.*

A Sketch of a Philosophy. Part III. The Chemistry of Natural Substances. Illustrated by two folding plates and 150 figurate diagrams of molecules in the text. By John G. Macvicar, LL. D., D. D. Williams and Norgate, 1870.

It is a hard matter to give a just account of this pamphlet. The views propounded by the author are so entirely different from those usually held by chemists, and according to the author's own statement they have been so little studied by others, that it is difficult to know exactly how to treat the subject. We should scarcely be justified in saying that the whole system is mere imagination, though some hold this opinion; but the book, though evidently written with the intensest earnestness, is the work of an enthusiast, which will explain the bitter complaints he makes against modern chemists for not taking more notice of molecular morphology. The author endeavors to explain the formation of all matter by the aggregation of the ethereal element, supposing that all bodies tend to assume a symmetrical and more or less spherical form. The simplest form of aggregation Dr. Macvicar considers to be the *tetrad*, consisting of four specks of the material element so arranged in space that they form the angles of a tetrahedron, the lines joining them indicating the attracting and repelling forces operating between the units. Two tetrads are also assumed to join base to base producing the *bitetrad*, and from these two forms, the tetrad and the bitetrad all the atoms and molecules of our planet are supposed to be produced. This tetrad by attracting another unit opposite to one of its faces constitutes a group of five units considered to be the atoms of hydrogen, and with the atomic weight of five. The author proceeds to show the mode of genesis of many other elements and compounds by the juxtaposition of these elemental forms. By calculation he can determine by his system the specific gravities of solids and liquids referred to water as unity, in a manner similar to that by which the densities of gases and vapors may be deduced by the old system. This alone would seem to show that the method deserves more attention from chemists than it has yet received. The non-reception of this molecular morphology may be ascribed to several causes; the diction of the author is peculiar, and he writes in a dogmatic manner, which might be expected in a theological work, but is not usually found in a treatise on natural science; then he pushes his inferences to such an extent (or, as some would say, rides his hobby so hard) that his conclusions appear somewhat ludicrous, unsupported as they are by experiment; thus he traces the coincidence between the assumed hexagonal form of the molecule of aqueous vapor and the shape of the minimum snow-flake and ice-flower, and the "inflorescence of plants of the monocotyledonous order, in which an aqueous issue predominates;" he thinks that one of the forms of aqueous vapor which occupies half the volume of the other, may possibly be converted into the second variety at a high temperature, and thus explain the explosion of steam boilers. Again the dimorphism of water may be

the cause of the production of animal heat; for water in the body may be transformed from one of its varieties into the other with evolution of heat; but on escaping from the body as perspiration, the inverse action takes place and cold is produced. But underneath all these extravagances there may be a stratum of truth, and we hope that either the author or some one who understands and accepts his views thoroughly, will so develop them as to insure their reception by chemists.—*Nature*.

Microscopal Manipulation. By W. T. Suffolk, F. R. M. S. Gillman, 1870. For sale by Van Nostrand.

This little book is the substance of a course of instruction given by Mr Suffolk in the spring to members of the Quekett Club. It will be useful to those persons who amuse themselves with microscopes, and do not care to purchase the scientific treatises of Dr. Carpenter or Dr. Beale. There is a chapter for the very youngest beginner on the various parts of an English compound microscope and their uses; then we have hints about the cutting of glass and the old directions as to making cells; mounting objects in balsam and in fluid is next dealt with, the old, old routine methods being detailed once again, with an allusion to Dr. Bastain's process with benzine. It is a pity that Mr. Suffolk has not made himself acquainted with some of the many methods of mounting and preparing objects in use on the Continent, which he might have picked up from Stricker's handbook, Frey's work, or other similar treatises. The best chapter in the book is that on polarized light, because it deals with a subject rather slighted in other works of this kind, in a clear and intelligent manner. We were not however, prepared for the following in a work on microscopical manipulation:—"The undulatory motion of light would seem to be expressed with considerable clearness in the 1st chapter of Genesis, when read in the original Hebrew, which, in common with other languages of the same family, is remarkable for the numerous inflexions of its verb, which gives it a delicacy and precision of expression unattainable in Western languages." Mr. Suffolk is quite right in considering that more attention should be paid to the use of polarized light as demonstrating structure, than has been done hitherto. A necessary step toward this is that microscopists should properly understand what are the conditions of production of color with the polariscope, and not be content with the mere sight of a pretty display. This little book of Mr Suffolk's will not do much, we fear, to convert what we may call microscopical play into microscopical science. Its receipts and directions are such as will be useful to the man who cares merely to make a series of pretty slides for exhibition to his friends, but do not help the student wishing to add to the storehouse of science. Nothing is said of the manner of studying living objects, living cells, living cilia, living protoplasm; nor do we find an allusion to the use of chromic acid, section instruments, methods of embedding of gold and silver staining, or other processes important to a working microscopist. The gold and silver-staining methods might have been given, if only for the benefit of those who like to make gorgeous preparations.

A small book on "Microscopical Manipulation," well up to the time, would be useful to students. We are sure Mr Suffolk does not wish to claim this position for his digest of the older hand-books. His excuse for its publication must be that in this country there are many people who indulge in the expensive peepshows sold by our English opticians, to whom it will really be acceptable.

It must not be imagined that we for one moment object to such amusements; on the contrary, they are altogether to be commended where more serious work cannot be undertaken—and only then.—*Nature.*

Reactions Schema fur die Qualitative Analyse, zum Gebrauche im Chemischen Laboratorium zu Berlin. Berlin, 1870. Verlag von August Hirschwald. London: Williams and Norgate. For sale by Van Nostrand.

This is a kind of pictorial analytical table in which the characters of the precipitates obtained are indicated by colored oblong spaces, which will, doubtless, be found very useful for impressing the appearances of the different precipitates on the mind of the student. The borax bead obtained with a compound of cobalt is represented by a blue oval, and the effect of ammonia on red litmus paper is shown by an oblong half red and half blue. The changes of color produced by the action of sulphuretted hydrogen on salt of mercury are indicated by an oblong of four different colors—white, yellow, orange, and black.

It is unfortunate that this table is not more complete: thus no means of obtaining the solution to be treated is mentioned; the destruction of organic matter before precipitation by ammonia and ammonia sulphide is omitted; the possibility of the precipitate in the third group containing phosphates, and the mode of examining it under such circumstances, is passed over entirely. The spectra of potassium, sodium, and lithium, are indicated by black lines with fine transverse white ones, representing the colored bands; but unfortunately no means are given to show which is the more refrangible end of the spectrum. Besides these omissions there are some misprints which will no doubt be corrected in a subsequent edition.—*Nature*.

The Gas Manager's Hand-Book;" consisting of Tables, Rules, and Useful Information for Gas Engineers, Managers, and others engaged in the manufacture and distribution of Coal Gas. By Thomas Newbiggin, A. I. C. E. London: W. B. King. 1870. For sale by Van Nostrand.

The class of books to which the one we notice belongs are among the most useful that issue from the press; and this one from the variety and amount of information it contains may be fairly described as one of the most useful of its class. It is a book which will be thoroughly appreciated by those who until now have had to seek in a dozen volumes for the information here collected into one, and who have had to spend hours in making calculations here done to their hands. But having said this we cannot dismiss the work without remarking the want of method displayed in the arrangement of the materials. We might almost say that there is no attempt at arrangement at all. This defect is not altogether compensated for by a full table of contents and a tolerably copious index, and in the assurance that a book so useful must soon arrive at a second edition, we would

suggest an entire re-arrangement of the contents.

At the commencement the compiler very properly introduces the raw material of gas-coal, and on pages 2–7 gives a table of the quantity of gas obtained from different coals and mixtures. This table should have been preceded by that of Mr. Lewis Thompson, given on pages 13–21, and then the whole of the information respecting the raw material would have been kept together. Retorts (about which more might have been said) and the other apparatus of distillation would very properly have come next. Following the process, we should come to the condensers and purifiers and their contents. Proceeding, we arrive at the gas-holders, and the finished article, after which all the information relating to gas might be given in proper order. The distribution would naturally come next, and we should have all that relates to mains and joints, and the flow and measurement of gas. The manufacture and distribution being thus followed step by step, the various tables and useful information, which scarcely admit of classification, might succeed, and the book be fitly concluded by the long tables of discounts, and the arithmetical tables. In this way the information given would be systematized, and a scientific character given to the book, which in its present state it scarcely possesses. We throw out this suggestion, which our space will not allow us to further develop, in the hope that the compiler will take it into consideration when preparing a second edition.

In conclusion, we may say that we noticed but few errors in the book, and these of but little importance; and can point to but few omissions, of which the same may be said, which speaks well for a book evidently compiled with some haste.

PRACTICAL TREATISE ON MINE ENGINEERING.—We have from time to time noticed the issue of the several parts of the second edition of the "Practical Treatise on Mine Engineering," by Mr. G. C. GREENWELL, F.G.S., and may now announce that the work, which is published by Messrs. Spon and Co., of Charing Cross, London, is completed. It was originally stated that it would consist of 16 half-crown parts, and this number has only been exceeded by one, so that for a couple of guineas the mining engineer and colliery viewer may possess himself of a really useful practical book, which, at the same time, will form a handsome ornament to his library. The work is divided into 9 chapters, embracing dissertations on the application of geology to mining; classes of rocks commonly met with in mining for salt, coal, and metallic ores; building materials; dykes, slips, and mineral veins; internal heat; metallic ores and minerals associated therewith, and with coal; smelting; boring and sinking tools; timbering; walling; tubbing; management of quicksands and clay; pumping engines and pumps; winding engines; ropes; pulleys; strength of timber, ropes, and other materials; the working of mines; underground haulage; working coal by machinery; copper; lead; tin; iron; salt; coal; ventilation; theory and practice; fire-damp; carbonic acid and other gases; explosions, and other casualties; and on various other matters of paramount importance to practical men. The basis of the work in its original form was a course of lectures delivered at the Newcastle-on-Tyne College of Practical Science in 1852, when mining institutes were unknown, and works upon the subjects treated of, at least in the English language, extremely scarce. The present edition is almost entirely re-written, yet the original character of the book has been retained. The author's object has been both to instruct the beginner in the art of mining, and to aid those who are more conversant with it in the execution of mining work. The changes which have taken place in the 16 years that have elapsed since the issue of the first edition have been great and important, and Mr. Greenwell, who has had the advantage of so much additional practical experience, has given his readers the full benefit of it, while supplying them with a record of the present position of mine engineering. The work is in every respect entitled to the patronage of mining engineers and mining students.

NOTES OF A COURSE OF SEVEN LECTURES ON ELECTRICAL PHENOMENA, AND ITS THEORIES, delivered at the Royal Institute of Great Britain. By JOHN TYNDALL, LL. D., F. R. S. London: Longmans, Green & Co. For sale by Van Nostrand. A brief summary, in 40 pages, of the history and present condition of Electrical Science. Invaluable to the scientific reader.

MISCELLANEOUS

A CORRESPONDENT of "Engineering" writing from New York says:—

The Board of Commissioners of Docks, having in charge the newly created Department of Docks of New York, very properly tendered the office of Engineer-in-Chief of the department to General George B. McClellan, whose well-known skill and ability as an engineer and an officer marked him as pre-eminently the man for the position.

This enterprise in its magnitude is well represented, and will be satisfactorily managed under the superior engineering direction of General McClellan, who, in this, has in hand the most interesting practical engineering problem in the United States; the solution and execution of which will be looked for most anxiously by the engineers of both Continents

THE REPAIRED CABLE.—Mr. Weaver, General Manager of the Anglo-American Telegraph Company, writes to the London "Times," under date of August 19, as follows:

"The cable familiarly known as the 1866 cable, the property of this Company, which was broken in two places at about 4½ and 75 miles, respectively, from Heart's Content, Newfoundland, has been successfully repaired, and is now in perfect working order.

"The latter breakage having occurred near a spot where the cable had been damaged on two previous occasions, it was thought advisable to shift it, and this portion of the cable has been relaid in a safer position. It is hoped that this operation will prevent the recurrence of these accidents."

OUR means of estimating the illuminating power of coal gas are notoriously imperfect. Without going far into the question, we may say that the comparisons of the light with candles and

lamps are equally open to objection, although we seriously think that either mode, if the experiment be properly made, is satisfactory for all practical purposes. Nevertheless there are many who think that a better standard is desirable. Several years ago Erdmann proposed to estimate the value of gas by ascertaining how much air was required in combustion to destroy the illuminating power, and he invented an instrument known as "Erdmann's Gas Prover." In this instrument, however, no attempt to measure the quantity of air consumed was made, but was only inferred from the size of the aperture opened to admit it. It was suggested by Schilling that for the instrument to have any scientific value, meters and other apparatus must be added, so that the gas and air consumed might be accurately measured, and the combustion take place under the same conditions of pressure, etc.

Mr. Wilkinson, of Sheffield, has just made an interesting communication to the "Journal of Gas Lighting," in which he describes a mode of estimating the quality of gas by measuring the amount of air consumed, and expressing the value of gas in standard candles. We must refer our readers to the full article for a description of the apparatus and mode of making the experiment. We need only mention here that Mr. Wilkinson uses as a standard unit or measure 0.2 of air, or equivalent to one candle, and calculates his results accordingly. Thus, in the experiments he gives, 0.1 ft. of gas required 0.324 of air to take away the light; and $0.324 \times 5 = 16.20$ candles, which is assumed to be the illuminating power of the gas. Other experimenters will probably take up this mode of examination, and we shall have further information upon it. The point to be satisfactorily settled is the amount of air equivalent to a candle.—*Mechanics' Magazine.*

Deep-Sea Sounding.—In 7,706 fathoms, 36 deg. 49 minutes South Latitude, 37 deg. 6 minutes West Longitude, this sounding was obtained on a calm day, in the course of a passage from Rio de Janeiro to the Cape of Good Hope. The sounding-line was $\frac{1}{10}$ of an inch in diameter, laid into one length, and weighing, when dry, 1 lb. for every 100 fathoms. The plummet weighed 9 lbs., and was 11.5 in. in length, and 1.7 in. in diameter. When 7,706 fathoms had run off the reel, the sea bottom was reached. Captain Denham states that Lieut. Hutcheson and himself, in separate boats, with their own hands drew the plummet up 50 fathoms several times, and after it had renewed its descent, it stopped on each occasion, abruptly, at the original mark, to a fathom, and would not take another turn off the reel. The velocity with which the line ran out was as follows:

	H.	M.	S.
The first 1,000 fathoms in......	0	27	15
1,000 to 2,000 "	0	39	40
2,000 to 3,000 "	0	48	10
3,000 to 4,000 "	1	13	39
4,000 to 5,000 "	1	27	6
5,000 to 6,000 "	1	45	25
6,000 to 7,000 "	1	49	15
7,000 to 7,706 "	1	14	15

The whole time, therefore, taken by the plummet in descending through 7,706 fathoms, or 7.7 geographical miles of 60 to the degree, was 9 hours 24 minutes, 45 seconds. The highest summits of the Himalay, Dhawalagiri, and Kinchinginga are little more than 28,000 ft., or 4.7 geographical miles above the sea. The sea-bottom has, therefore, depths greatly exceeding the elevation of the highest pinnacle above its surface. The strength of the line tried before the sounding, was found to be equal to bear 72 lbs. in air. The 7,706 fathoms which ran out, weighed, when dry, 77 lbs. exclusive of the plummet, 9 lbs. Great care was taken in the endeavor to bring the plummet again to the surface to show the nature of the bottom, but, whilst carefully reeling in, the line broke at 140 fathoms below the water-line, carrying away a Six's thermometer, which had been bent on at 3,000 fathoms.—*Electric Telegraph and Railway Review.*

Lead in America.—A white lead manufacturer in St. Louis, Mobile, has recently ordered from Europe 800 tons of lead, costing at that city, freight and duties paid, $7.35 per cwt., or $3\frac{1}{2}$ mills per lb. over the present prices of soft Missouri lead. It is claimed that the lead now mined in Missouri is filled with impurities, so as to be unfitted for the manufacture of white lead. Lead mining is also confined to persons of slender means, who sink shafts in search of crevice deposits, pockets, or float mineral, and success is a mere matter of chance. This kind of mining, it is asserted, has nearly exhausted the surface beds of Galena and other parts of Illinois, in Wisconsin, Iowa, Missouri, and Arkansas. While the production of lead in the West has fallen to 11,000 tons per annum, the consumption in the West alone has risen to 15,000 tons. The consumption of lead in the United States in 1869 amounted to 50,000 tons, of which 37,500 were imported. The freight of lead, it may be mentioned, is very low, in consequence of the desire of shipmasters to obtain ballast easily handled. Thus the freight upon lead from Europe to St. Louis, including handling at New Orleans and river transportation, is only 32 cents per 100 lbs., or less than the railway charges for lead brought from the mines in Northern Illinois. The freight to New Orleans is only 7 cents per 100 lbs.—*Iron Age.*

When copper has heretofore been detected in animal matters, its presence has always been regarded as accidental or fortuitous, and not as essential. Traces of the metal, it is true, have been found in some living animals, but these have doubtless been assimilated, as in the case of the oyster from copper salts, which have been carried in solution from mine drainings down to the mouths of rivers, without doing either good or injury to the animal. But in the turaco, or plantain-eater of the Cape of Good Hope, a bird celebrated for the remarkable beauty of its plumage, this metal plays, according to Professor Church, of England, a very important part. It is an essentiality in the composition of the red coloring matter of the bird's plumage, constituting about six per cent. of the same, and cannot be removed from it without a destruction of the matter; in effect, all the ordinary means fail to detect it without the pigment be first destroyed and the ash then examined for the metal. The existence of the red plumage is dependent upon copper, which, obtained in small quantities from the food, is stored up in this strange manner in the system of the animal, thus elaborating an element which is ordinarily regarded as poisonous to the animal economy, and which in this case seems to

serve the single purpose of decoration—an example to warn us against the fallacy of taking an entirely utilitarian view of the plan of creation.—*American Exchange and Review.*

INFLUENCE OF CANNON-FIRING UPON RAIN.—M. Charles La Maout, apothecary at Saint Brieuc, in France, has published some interesting observations on the influence of artillery-firing upon the fall of rain and the force of the wind. During the siege of Sebastopol, soon after the firing commenced the sky became obscured with clouds and a fine rain began to fall, which was sometimes followed by a deluge or whirlwind. Immediately, and as a consequence of the condensation, the mercury in the barometer rose in proportion to the violence of the cannonading. A chart of the movements of the barometer afforded a good indication of the bombardment. The author then proceeds to show how rain could be produced at will by a judicious discharge of artillery. There is no doubt that this would be a better use of cannon than the wholesale slaughtering of men, but whether rain could be produced at will in this way is another question. There is some confirmation of the theory in the fact that a violent rain fall has attended the recent engagement of troops near Metz, in France. The subject is one quite worthy of investigation, and if it were found to be expedient, the proposition of the author to establish meteorological stations with suitable artillery ought to be carried into execution.—*Journal of Applied Chemistry.*

CONDENSERS.—An invention of Mr. A. Barclay, Kilmarnock, relates to an arrangement of condensing apparatus, wherein an ejector is used in combination with a condensing chamber or vessel attached to cylinders of steam-engines or other receptacles wherein a vacuum or partial vacuum has to be formed. One passage of the ejector is attached to the lower part of the condensing chamber, and by means of it the injection water and water of condensation resulting from the steam or vapor in the chamber is drawn off. Another passage of the injector is connected with an opening at a higher level in the condensing chamber, and when the water in such chamber rises up to and above this opening, both water and air, and any uncondensed vapor that may be in the chamber, are drawn off by such opening until the water-level is reduced below the lower edge of the said orifice, after which air and uncondensed vapor only are drawn off through it.

ELECTRO-METALLURGY.—An invention of Mr. T. Chutaux, Paris, consists in keeping the solution constantly agitated by any suitable contrivance, and to operate this contrivance by the same electric battery which serves to apply the metals on the objects to be electro-plated. This is done by placing a revolving shaft, with a hellice at its lower end, vertically in the middle of the receptacle containing the solution. Its upper end, crossing a support composed of isolating material resting on the receptacle, is attached by an endless band passing over grooved pulleys to the shaft of a fly-wheel operated by a connecting-rod attached to an armature acted upon by the electro-magnet attached to the battery. The rotation given to the shaft is transmitted to the hellice, an ascending current is established in the middle of the receptacle, and a descending current towards its sides, in such a manner that all the parts of the objects operated upon are in a continual contact with a liquid of equal richness throughout, and the metal is thus deposited regularly and uniformly.

PROFESSOR GOULD has found that the velocity of the electric waves through the Atlantic cables is from 7,000 to 8,000 miles per second, and depends somewhat upon whether the circuit is formed by the two cables or by one cable and the earth. Telegraph wires upon poles in the air conduct the waves with a velocity a little more than double this ; and it is remarked, as a curious fact, that the rapidity of the transmission increases with the distance between the wire and the earth, or the height of the support. Wires buried in the earth likewise transmit slowly, like submarine cables. Wires upon poles, but slightly elevated, transmit signals with a velocity of 12,000 miles per second, while those at a considerable height give a velocity of 16,000 or 20,000 miles.

THE following estimate of the cost of war appears in "Cosmos" : The war in the East caused the death of 256,000 Russians, 107,000 French, 45,000 English, and 1,600 Italians. The Polish insurrection resulted in the death of 190,000, and the freeing of Greece 148,000. Africa has cost France somewhat about 146,000 men. The war in Italy was the cause of loss to the extent of 59,664 Austrian, 30,220 French, 23,610 Italian, 14,000 Neapolitan, and 2,370 Papal soldiers. Since 1815 Europe has lost 2,762,000 men on the field of battle. The Italian war cost 1,485,000,000 of francs. The war in the East cost Russia 2,328,000,000 francs ; France, 1,348,000,000 francs ; England, 1,320,000,000 francs ; Turkey, 1,060,000,000 francs ; and Austria, 470,000,000 francs.

A CUBIC inch of gold is worth (at £3 17s. 10½d. per ounce) £42 ; a cubic foot, £72,562 ; a cubic yard, £1,959,552. The amount of gold in existence at the commencement of the Christian era is estimated to be £85,400,000 ; at the period of the discovery of America, it had diminished to £11,400,000 ; after the occurrence of that event, it gradually increased, and in 1600 it attained to £21,000,000 ; in 1700, £70,000,000 ; in 1800, £225,000,000 ; in 1843, £100,000,000 ; in 1853 to £600,000,000 ; at the present time the amount of gold in existence is estimated to be £1,200,000 000, which, welded into one mass, could be contained in a cube of 26 ft. Of the amount now in existence, £800,000,000 are estimated to be in coin and bullion, £200,000 in watches, and the remainder in jewelry, plate, etc.

THE MANUFACTURE OF TAR PAVEMENT.—In most provincial towns there are two important bodies of men, the Paving Commissioners and the Gas Directors. The one is pledged to keep the rates low and the other to keep the price of gas as low as will enable them to provide the statutory dividend. As one means of insuring a cheap supply of gas is to create a greater demand and obtain a better price for the residual products, I have great pleasure in introducing a subject the adoption of which would be advantageous to both of these bodies. It is not a new one, but has hitherto been a neglected source of revenue to gas companies and will also be a great benefit to the public. That subject is tar pavement. In some counties, such as Yorkshire, where stone is as abundant as

brain is said to be, tar pavement will receive but little attention, but in the eastern and some other counties where the same conditions do not exist, but where York flag costs 7s. per yard laid, tar pavement is a desideratum. In such districts there is a scramble for pavement, and on account of the high price, unless a paving commissioner reside in the street, it remains unpaved. The foot passenger has thus to his great discomfort to walk on gravel or, as in Colchester, on stones laid in such a manner as would have done discredit to any of the Roman paviers who once resided in that neighborhood.

Tar pavement may be made of the ordinary cinder dirt produced in gas works of shingle or of a mixture of both. The material is burnt in heaps like ballast, and when hot is mixed with tar. In practice I make a small fire of coke on the ground and cover it with cinder dirt or shingle. When this layer is hot another is added, and so on in succession until a large enough heap has been provided. The tar is now boiled in an iron copper and taken when hot and mixed with the hot material from the heap already described, in quantities of two bushels at a time, in about the proportion of one gallon to every bushel of cinder dirt, and slightly less than a gallon for the gravel. It is turned over and over with the shovel until every part of the material has got a covering of tar. Then I pass the whole through a sieve with a $\frac{5}{8}$ in. mesh, and part of it through another with $\frac{1}{4}$ in. mesh, and put the whole in heaps until required, as it may be kept for months before being laid down.

Before the pavement is laid, an edging should be provided about 2 in. thick, and projecting 2 in. above the surface of the ground to be covered, which should be tolerably even. It is advisable to have the ground next the curb well trodden on and rammed before the pavement is laid, otherwise there will be an unseemly hollow next the curb. In laying, the rough stuff is put down first and rolled tolerably firm, then the second quality is put on, then the third, and when the whole has been raked level a little of the finest material is sifted on through a sieve with $\frac{1}{8}$ in. meshes, and a little fine white shingle or Derbyshire spar is sprinkled on the top. The whole must now be well rolled. The best roller is a water ballast roller, which at first is used without ballast and well wetted to prevent adhesion of the material, and when the pavement is slightly consolidated the full weight should be applied.

For heay cart traffic the material should be made of shingle only heated and mixed as above and well rolled. Both descriptions of pavement are laid best and most easily in warm weather, and should be rolled when the sun has warmed it well. Those parts in angles should be well rammed and trimmed off with a light shovel.

Though apparently a simple manufacture there is a little difficulty in ascertaining the proportion of tar to gravel or cinder dirt. A little experience will only be necessary in this as well as in all other manufactures, to enable any one to carry it out successfully.

I cannot recommend this pavement too much, as it is cheap, wears well, and can be easily repaired. The color, which never can be made to equal York flag, and the smell for some time after it is laid, are the only objections to its use; it can be laid with a good profit in any district at 1s. 4d. per square yard, and besides being a boon to the public, who must otherwise walk on the gravel, is a great advantage to gas companies. To them it provides a remunerative outlet for their tar, which often otherwise must be sold at a low price to distant distillers.

Since writing the above I have seen a paragraph in the "Times" which states that it is proposed to pave the streets of London with stone laid in asphalt instead of lime grout. This is just a more systematic application of the above described plan. For the tar by being boiled and thrown on hot stones becomes an elastic asphalt.

THE AILANTUS AS A TIMBER TREE.—Both in France and America this tree is said to be gaining ground in the estimation of practical men. Experiments made in France (says the "American Agriculturist") show the wood to have less density than that of the oak, and greater than that of the elm, while it is superior to either of the two in elasticity and tenacity. Ailantus planks have been exposed to the weather for 27 years, without shelter or paint, and the wood is still perfectly preserved. The wood is useful for agricultural implements, and it neither warps nor cra ks. It saws readily, and afterwards acquires great hardness under exposure to the air. The ailantus grows so freely in America that it ought not to be a difficult matter to ascertain whether its timber is as serviceable there as it is said to be in France.

COCHINEAL, a common dyeing material, is often adulterated by being softened and swollen with steam, and then rolled about in sulphate of baryta, which gives the substance the appearance of a superior article. The fraud can, however, be readily detected, since, in the first place, the genuine article contains only from 4 to 6 per cent. of water, and this mode of adulteration increases that quantity to 11 per cent.; secondly, the quantity, as well as the quality, of the ash is entirely changed; 19.50 to 20 per cent. of sulphate of baryta has been found in the ashes of adulterated cochineal; the ashes, when no adulteration has been attempted, contain no traces of this salt.

AN observation has been made which has resulted in the discovery of a new mode of estimating the strength of alcohol. M. Ducaux has been experimenting on the superficial tension of liquids with an apparatus which exhibits the variations of it in a very remarkable way. A dropping tube, for instance, is arranged to let fall in air 100 drops a minute. If, now, the experiment be repeated in air saturated with vapor of alcohol, instead of 100 drops, 110 will fall in the minute. This is caused by the solution of some alcohol in the water, by which the superficial tension of this liquid is diminished. Further experiments led to the discovery that the strength of alcohol could be exactly determined by ascertaining how many drops would fall in a minute from a given orifice.

BLAST ENGINES.—An invention of Mr. W. Neill, Jun., Bold, Lancashire, consists in the use of slide valves to prevent the air which has been compressed from escaping at the outlet. For this purpose the inventor employs apparatus whereby the air passages are closed when the piston arrives at the end of its stroke, and by which the said valves are so held until a portion of the return stroke has been effected, after which the inlet and outlet passages are fully opened.

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IRON ARCHES.

BY W. AIRY.

From "Engineering."

The practical theory of arches has probably made less progress than any other branch of engineering knowledge. There are in common use two forms of arch, entirely distinct in their mechanical arrangement and source of strength, viz., the voussoir arch built of separate stones, and the continuous arch of wood or iron. The first of these has, indeed, received much attention from mathematicians, but from the unsatisfactory and indeterminate character of the problem of the arch, when the friction between the stones is considered, the theory has in general been confined to the various forms of equilibrated arches, which stand in virtue of the adjustment of the loads on each voussoir, without calling into play any friction forces between the voussoirs. It is, however, manifest that, for a heavy movable load, such as almost all arches are liable to, any theory of the arch which neglects friction is very far from complete, and such is the power of this friction to secure the stones of an arch, that in practice the theoretical forms are rarely considered, and the shape of the arch is decided upon in accordance with points of appearance or convenience. The friction, indeed, never reaches its limit in practice, and arches fail, not by the voussoirs slipping upon one another, but by the resultant line of thrust falling too near to the outside of the arch. Since, then, the friction never reaches its limit, it is impossible to say what its value may be for a given disposition of load, and hence the indeterminate nature of the problem, as will be pointed out hereafter.

For the continuous arch there is, so far as the writer is aware, no published investigation of a practical character. This form of arch is mainly due to the rapid progress of construction in wrought iron, and from its strength and security it has become the favorite form of arch for bridges of large span. It is, therefore, of great importance to investigate, however approximately, the strains on such arches, and there is less difficulty and uncertainty in doing so for a continuous arch of wrought iron than for a voussoir arch, because in general the depth of the ribs of a continous arch is small compared with the radius of the arch, and this circumstance offers great facilities for approximation. The main object of the present communication is to investigate the strains on a continuous iron arch.

It will, however, be proper, first, to examine into the conditions of equilibrium of a voussoir arch, in order to show the indeterminate character of the problem, as also to point out the different nature of the forces which the two forms of arch are able to bring into play to resist rup-

ture, and on which they rely for their stability. This may be done shortly, as follows :

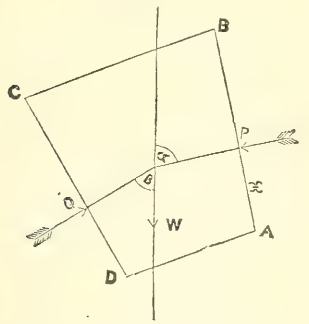
Consideration of an equilibrated arch, i.e., an arch constructed of voussoirs whose weights are so adjusted that every voussoir is in equilibrium without calling into action any force or friction between adjacent voussoirs.

(It will be found proved in works on mechanics that this will be the case when the weights of the voussoirs are proportional to the difference of the tangents of the angles which their joints make with the vertical.)

In this case there will be no forces acting at the joints of a voussoir, but the pressures of the adjacent voussoirs ; these will all be normal to the joints at which they act, and the resultant of such forces at each joint will, therefore, also be normal to the joint.

Let, then, A, B, C, D, Fig. 1, be a stone

[FIG. 1.



of an equilibrated arch. This stone is in equilibrium under the action of three forces, viz. : The pressures at the joints collected into their resultants, P and Q, and the weight, W, of the stone. These three forces must, therefore, meet in a point in the vertical through the centre of gravity of the stone, as shown in the figure, and since the position of the stone is supposed known, the angles a and β, which the directions of the side forces make with the vertical, are also known. The force P will be known in terms of the weights of the voussoirs between the crown of the arch and the stone in question, and may be assumed to act at a distance x from A, measured along the joint A B. Then resolving the forces vertically and horizontally, and taking moments about the point D, we have the three following equations :

$$\text{R cos. } \beta - \text{P cos. } a - \text{W} = 0$$
$$\text{Q sin. } \beta - \text{P sin. } a = 0$$
$$f\,(x, \text{Q. etc}) = 0$$

where $f\,(x$, Q, &c.) means an expression involving the quantities, x, Q, &c.

All the quantities involved in these three equations are known, except Q and x. Consequently there are three equations, and only two unknown quantities, and it follows that one of the equations, evidently the equation of moments, is a consequence of the other two. Since, then, the equilibrium of the voussoir is sufficiently provided for without using the equation of moments, which alone involves the point of application of P, it follows that for the equilibrium of the stone it is immaterial at what point of the stone the force P is supposed to act, and x may have any value that the depth of the stone will allow. Thus as regards the equilibrium of a single stone, the position of the resultant line of thrust is wholly indeterminate.

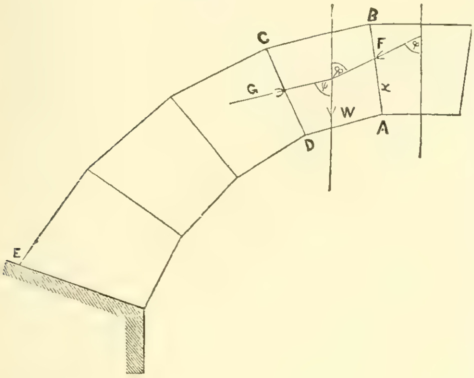
When, however, the arch, of which A B C D is a single voussoir, is considered collectively, it will be seen that the range of variation of the resultant line of thrust is reduced within more moderate limits. For the resultant line of thrust must not pass out of the arch either above or below, and this condition will reduce the range of x more or less according to the shape of the arch and the depth of the stones. Nevertheless there will in general remain a considerable range of variation, and the exact position of the resultant line of thrust is an indeterminate problem.

Consideration of an arch with friction between the voussoirs.

Suppose that an equilibrated arch as above considered has its equilibrium destroyed by the addition of a load upon the crown of the arch. Then the pressures at all the joints throughout the arch will be increased, and unless the friction between the stones were to come into play, each voussoir, as A B C D, would be thrust out of the arch upwards. At every joint, however, a force of friction will be called into action to oppose this tendency, which, together with the normal pressure between the adjacent stones, will be represented by a resultant force inclined to the joints

at an angle dependent on the amount of friction called into play. Let F and G represent these resultant forces in the case of the voussoir in the diagram, Fig. 2,

FIG. 2.



inclined to the vertical at unknown angles ϕ and ψ, and let the force, F, be supposed to act at a point distant x from A. Then, as before, the stone is in equilibrium under the action of the three forces, F, G, and W, and the conditions of equilibrium give rise to the following equations :

$$G \cos. \psi - F \cos. \phi - W = 0$$
$$G \sin. \psi - F \sin. \phi = 0$$
$$f(x, G, F, \phi, \psi, \text{etc}) = 0$$

where $f(x, G, F, \phi, \psi, \text{etc.})$ means an expression involving the quantities x, G ϕ, F, ϕ, ψ, etc.: F is known in terms of the angle ϕ and the weights of the voussoirs, etc., between the crown of the arch and the stone in question.

Here, then we have three equations and four unknown quantities, viz., x, G, ϕ, and ψ; if we eliminate two of them, as G, and ψ, we obtain an equation of condition between x and ϕ, which will be satisfied by an infinite number of pairs of values of x and ϕ. Now ϕ depends upon the amount of friction acting along the joints, A B, and the equation of condition between x and ϕ shows that the amount of this friction may vary, provided that x undergoes a corresponding variation, as defined by the equation. Thus in this case also x has a range of variation, within the limits of which equilibrium may subsist, and the precise position of the reluctant line of thrust is, as before, an intermediate problem.

It is now possible to investigate the specific points of difference between the arch constructed of unconnected voussoirs and a continuous arch as constructed in wood or iron. This will be best demonstrated by considering the forces which the two forms of arch are able to bring into play to counteract the bending moment at any point of the arch. In the case of the voussoir arch above considered, let the portion A E, between the joint A B and the abutment, be supposed united in one rigid mass. Then the forces which act upon the mass A E are, (1) the thrust of the abutment; (2) the weight of the mass A E, acting through its centre of gravity; (3) the pressure at the joint A B. Let it be supposed that the mass A E is in equilibrium for a given disposition of load, when the force F acts at a distance [x] from A. Then the moments of the three forces about the point B balance one another, and the joint A B has no tendency to open either at A or at B. If now the disposition of load be altered, the forces will be altered and their moments about B will no longer balance one another, and there will be a resultant moment tending to make the joint open either at A or at B. Let it be supposed that the tendency of this resultant moment is to make the joint open at A. Then the point of application of the force F (which tends to open the joint at A) shifts nearer to B (as is permitted by the conditions of equilibrium stated in the last paragraph) so as to diminish the effect of its moment about B, and thus equilibrium is maintained. Finally, when the tendency to open at A is so great that it cannot be counteracted except the point of application of the force F retires past B, and outside the arch, then the joint opens at A, and the arch falls to pieces. From this is seen the great importance of depth for the stones of a voussoir arch. As regards the strain on the material of the arch this will be, of course, a simply compressive strain, distributed more or less according to the degree of elasticity which exists in the stone. It is certain that the edges of the voussoirs would crush or flake off long before the resultant line of thrust was driven to the outside surface of the arch; but the problem, as regards the strain on the materials, is, generally speaking, indeterminate, and the rules which have been established on the subject are entirely empirical.

In the case of the continuous arch it must be understood that there is acting

at every point a bending moment and a thrust force. The effect of these two as regards the equilibrium of the mass A E, will be represented by their resultant, which will be a single thrust force, acting at a point removed from the centre of the section, and precisely similar to the thrust force F of the voussoir arch ; but as regards the strain on the materials the effect is far more definite than in the case of the voussoir arch. For a continuous arch can bring into play forces of tension as well as forces of compression, and the bending moment is met by an opposite moment about the neutral axis of the arch, which is supplied by the resistance of the materials in the manner of an ordinary plate-girder. Thus in this case the arch relies upon the strength of the materials to resist the bending moment of the forces, and the total effect of the forces upon the material of the arch will be ascertained by combining with this moment the thrust of the arch, which will be known in terms of the weights and other forces which act upon the arch. This force of thrust will clearly increase the strain upon that side of the arch which is in compression in consequence of the bending moment, and will relieve that side which is in tension, so that in general the arch would fail by compression ; but in any case the stability of a continuous arch depends in a strictly definite manner on the strength of the materials, and thus it becomes possible, by using reliable materials of great strength, such as cast and wrought iron, the action of which under tension and compression is well known, to cross a wide span with much less depth of rib than would be required by a voussoir arch.

There yet remains a force which does not enter into the consideration of the bending moment either in the case of the voussoir arch or the continuous arch, viz.: the force along the surface of the section, which in the voussoir arch takes the form of friction between the joints, as already described, and in the continuous arch takes the form of a shearing force, which can be expressed in terms of the thrust force and the inclination of the curve drawn through the successive positions of the resultant force to the section in question. This shearing force will in general have but a very slight effect on the security of an arch.

The following investigation of the bending moment at any point of an iron arch is due to the Astronomer-Royal, and although the results are given only for the ordinary case of a circular arch, yet the method is equally applicable to the case of more complicated arches. As a preliminary to the investigation, the conditions of breaking and bending of an iron bar are prescribed in the two following propositions. Throughout the investigation the unit of length is supposed to be 1 ft., and the unit of weight the weight of a cubic foot of iron.

PROPOSITION I.

To investigate the criterion of breaking of a bar, by bending forces whose angular moment is M, at any particular point of the bar.

The bar will break when the bending force at the surface on the extended side is equal to the tension strength of iron. Call this (t), where (t) is to be expressed numerically by the number of feet in length of any bar who e weight will tear that bar asunder. Suppose the section of the bar to be a parallelogram (there is no difficulty in making a more general supposition when necessary), (b) its whole depth in the direction in which it will bend (the plane of the arch), and (a) its thickness. And suppose the neutral point to be in the centre of the bar's depth. Measure (x) from the centre towards the stretching side. The surface of that part of the section which corresponds to δx is $a.\ \delta x$; the extension is $\frac{2x}{b} \times$ extension at the tearing surface; the tension force for surface 1 is $\frac{2x}{b} \times$ tearing force $= \frac{2tx}{b}$; the tension force for surface $a.\ \delta x$ is $\frac{2at}{b} x.\delta x$; its moment round the neutral point is $\frac{2at}{b} x^2.\delta x$; the sum of all the moments from the centre to x is $\frac{2at}{3b} x^3$. Taking this from $x = -\frac{b}{2}$ to $x = +\frac{b}{2}$ (which includes the thrusting effect of the compressed side), the entire sum of moments is $\frac{4at}{3b} \cdot \frac{b^3}{8} = \frac{ab^2 t}{6}$. At the moment of breaking this must $=$ M, or $\text{M} = \frac{ab^2 t}{6}$.

PROPOSITION II.

To investigate the bending produced in a bar by bending forces whose moment is M; no consideration of breaking being entertained.

Suppose that a weight hung to a bar whose section is 1 will extend the bar by $e \times$ bar's length (e is a very small fraction). Let (r) be the radius of the curvature which the application of the moment M produces in the neutral line. At the distance (x) from the neutral line the fibres are lengthened in the proportion $r : r+x$, or by the $\frac{x\text{th}}{r}$ part of their length. And since an extension $e \times$ fibres' length corresponds to weight 1 on section 1, therefore an extension $\frac{x}{r} \times$ fibres' length corresponding to weight $\frac{x}{r.\,e}$ on section 1, and therefore to weight $\frac{x}{r.\,e}.\ a.\ \delta\,x$ on section $a.\ \delta\,x$. Therefore, the force actually exerted by the part $a.\ \delta\,x$ in its stretched state is $\frac{a}{r.\,e}.\ x.\ \delta\,x$, and its moment is $\frac{a}{r.\,e}.\ x^2.\ \delta\,x$; the sum of all the moments is $\frac{a}{3.a.e}x^3$; which from $x=-\frac{b}{2}$ to $x=+\frac{b}{2}$ becomes $\frac{2\ a}{3.\ r.\ e}.\ \frac{b^3}{8}=\frac{a.\ b^3}{12\,r.\,e}$. This sum of moments resisting the bending is equal to the moment producing bending $=$ M. Therefore, $\frac{1}{r}=\frac{12.\ e}{a.b}.$ M. This $\frac{1}{r}$ may be taken as the measure of curvature.

In the following investigation, if the dimensions of the bar were supposed to vary, we must use the factor $\frac{12.\ e}{a.\ b^3}$; but if we consider the dimensions of the arch to be everywhere the same, we may put E for $\frac{12.\ e}{ab.^3}$, and then $\frac{1}{r}=$ E M.

The course of the investigations will be:

1. The arch will be supposed to be an arc of a circle, of uniform breadth and depth throughout, loaded with a weight on its crown. (Probably there will be no difficulty, though some complexity, in varying both these conditions.) It is assumed that the depth of the arch is small compared with the span of the arch.

2. It will be supposed that the feet of the arch are prevented from spreading asunder. (There is no difficulty in supposing the feet free to spread; but this is not the case in practice.)

3. At any point of the arch, the moment M will be investigated, including terms which depend on the horizontal forces H, H, which prevent the feet of the arch from spreading asunder.

4. The impressed curvature at every part of the arch will therefore be found, including effects of H.

5. From these curvatures will be found the spread given to the feet of the arch, still involving H.

6. This spread will be made $=0$, whence H will be determined.

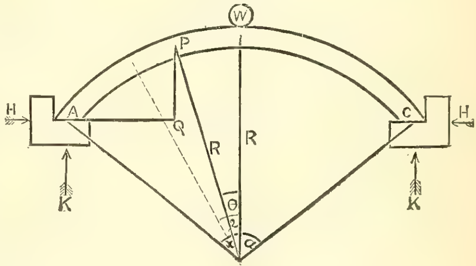
7. The value of H will be substituted in M (No. 3), and the explicit value of M at every point of the arch will be found.

8. The point of the arch will be found at which $\frac{6\ \text{M}}{a.b.^2t}$ (Prop. I.) is maximum; that point is the point most likely to break. If $\frac{6\ \text{M}}{a.b.^2t}$ is greater than 1, the arch will break there.

PROPOSITION III.

To investigate the moment M at any point of the arch.

FIG. 3.



Let A C be the arch, and P the point at which the bending moment is required to be known. The position of P is defined by its radial distance R from O, the centre of the circle, and the angle ϕ, which this radius makes with the vertical. P Q is a vertical from P, and A Q a horizontal line meeting P Q in Q. (α) is the angle of the half arch, and $a.\ b.$ the sectional area of the rib.

The abutments are drawn in the rectangular state to show the resolved actions of the supporting forces; but they would be exactly the same if the abutments were inclined.

It is supposed in the figure that the bearing of the arch is at the point A, at

the moment of breaking. Strictly speaking, it will be most probably at B; but in what follows this merely makes the difference that we ought to have taken a rather longer arch, so that the radius to the assumed bearing point would have been directed towards B.

It is supposed that the arch is originally planted without any strain, or in exactly the same form which it would have taken if laid sideways on a horizontal plane.

For estimation of the moment about P, it will be sufficient to take one side of P (inasmuch as that on the opposite side is necessarily equal to it). Take it on the side towards A; then the whole moment to produce bend at P consists of the following parts:

The weight of the portion from P to A
The force H

in one direction, bending A downwards and inwards—and the force $K = R \propto a\, b + \frac{W}{2}$, in the opposite direction, bending A bending A upwards and outwards.

I. The portion from P to A.

The mass between ϕ and $\phi + \delta\phi$ is $a.\, b.\, R.\, \delta\phi$; its horizontal distance from P is $R\ (\sin\phi - \sin\theta)$; its moment round P is $a.\, b.\, R^2\ (\sin\phi - \sin\theta)\ \delta\phi$; the entire moment is $a.\, b.\, R^2\ (-\cos\phi - \sin\theta.\, \phi)$; taking this between the limits $\phi = \theta$, $\phi = \propto$, the entire moment around P of the portion from P to A becomes $a.\, b.\, R^2\ (\cos\theta + \theta\sin\theta - \cos\propto - \propto\sin\theta)$.

2. The force H.

Its moment round $P = H \times P\, Q =$

$$H.\, R\ (\cos\theta - \cos\propto).$$

3. The force $R \propto a\, b + \frac{W}{2}$

Its absolute moment is

$\left(R \propto a\, b + \frac{W}{2}\right) \times A\, Q = \left(R \propto a\, b + \frac{W}{2}\right) + R$ $(\sin\propto - \sin\theta)$: but as this is in the opposite direction it must be taken

$$\left(R \propto a\, b + \frac{W}{2}\right) \times R\ (\sin\theta - \sin\propto).$$

Hence the entire value of M at P is

$$(a\, b\, R^2 + H.\, R)\ (\cos\theta - \cos\propto) + a\, b\, R^2\ (\theta - \propto)\ \sin\theta + (R^2\, a\, b\, \propto + \frac{R\, W}{2})\ (\sin\theta - \sin\propto) =$$

$$(a\, b\, R^2 + H\, R)\ (\cos\theta - \cos\propto) + a\, b\, R^2\ (\theta\sin\theta - \propto\sin\propto) + \frac{R.\, W}{2}\ (\sin\theta - \sin\propto).$$

PROPOSITION IV.

To find the impressed curvature at P.

By Proposition II., the reciprocal of the radius of the circle into which straight fibres are bent is $E \times M$. Or, the reciprocal of the radius of the circle into which straight fibres are bent, omitting the general factor E R, is

$$(a\, b\, R + H)\ (\cos\theta - \cos\propto) + a\, b\, R(\theta.\sin\theta - \propto\sin\propto + \frac{W}{2}(\sin\theta - \sin\propto).$$

If then we consider two points on the neutral line whose curve distances from the crown of the arch are $R.\, \theta$, $R.\, (\theta + \theta\, \delta)$, the fibres at the second point are bent downwards with respect to their original direction in regard to those of the first by the angle

$$E.\, R^2.\, \delta\theta \left\{(a\, b\, R + H)\ (\cos\theta - \cos\propto) + a\, b\, R\ (\theta\sin\theta - \propto\sin\propto) + \frac{W}{2}(\sin\theta - \sin\propto\right\}$$

PROPOSITION V.

To find the spread of the foot A.

(It will be convenient to estimate it positive in the inward direction.) Let the bend at the end of the last proposition be called $\Theta.\, \delta\theta$. Join A and P by a straight line. The bending will throw A through the space $A\, P \times \Theta.\, \delta\theta$, in the direction perpendicular to A P. The resolved part of this inwards is

$$A\, P. \times \Theta.\delta\theta \times \frac{P\, Q}{P\, A} = P\, Q \times \Theta\, \delta\theta =$$

$$R.\ (\cos\theta - \cos\propto).\ \Theta.\, \delta\theta. = E.\, R.^3\, \delta\theta \times$$

$$\left\{\begin{array}{c}(a\, b\, R + H)\ (\cos\theta - \cos\propto)^2 \\ a\, b\, R \times (\cos\theta - \cos\propto) \times (\theta.\sin\theta - \propto\sin\propto) + \\ \frac{W}{2} \times (\cos\theta - \cos\propto) \times (\sin\theta - \sin\propto)\end{array}\right\}$$

This must be integrated from $\theta = 0$ to $\theta = \propto$, to obtain the entire inwards spread of A, and, without giving the details of the integration, the entire expression for the spread of A inwards, omitting the factor $E\, R^3$, appears as

$$(a\, b\, R + H \left\{-\tfrac{3}{2}\sin\propto\cos\propto + \propto\, (\tfrac{1}{2}\sin^2\propto + \tfrac{1}{2}\cos^2\propto)\right\}$$

$$+ a\, b\, R \times \left\{-\tfrac{3}{4}\sin\propto\cos\propto + \propto\, (\tfrac{3}{4}\cos^2\propto - \tfrac{3}{4}\sin^2\propto) + \propto^2\sin\propto\cos\propto\right\}$$

$$+ \frac{W}{2} \times \left\{-\cos\propto + \cos^2\propto - \tfrac{8}{2}\sin^2\propto + \propto\sin\propto\cos\propto\right\}.$$

PROPOSITION VI.

To determine the value of H.

In this step is embodied the consideration of the lateral action on the abutment. If we omit H in every part of the investigation, we suppose that the ends of the arch rest on the top of flat piers. If we suppose, as above, that the spread is calculated relatively to what it would have been without any strain, and if we then (as we proceed to do) make the spread $=0$, this implies that the arch is planted in abutments, allowing only the same width as if the arch had been laid flatwise on a floor; now making the spread $=0$, we obtain

$$H \times \left\{ \tfrac{3}{2} \sin \alpha . \cos \alpha - \alpha (\tfrac{1}{2} \sin^2 \alpha + \tfrac{3}{2} \cos^2 \alpha \right\}$$
$$= abR \times \left\{ -\tfrac{9}{4} \sin \alpha . \cos \alpha + \alpha (\tfrac{9}{4} \cos^2 \alpha - \tfrac{1}{4} \sin.^2 \alpha) + \alpha.^2 \sin. \alpha \cos \alpha \right\}$$
$$\frac{W}{2} \times \left\{ - \cos \alpha + \cos^2 \alpha - \tfrac{1}{2} \sin^2 \alpha + \alpha \sin \alpha \cos \alpha \right\}$$

which gives H in two troublesome fractions. There is no difficulty in expressing it in any numerical instance.

It is worthy of remark here that, though it has been absolutely necessary to use the law and modulus of elasticity or extensibility in the investigation, yet they totally disappear from the result (which does not contain E).

(TO BE CONTINUED.)

THE LOSS OF THE "CAPTAIN."

From "The Engineer."

Never was journalist called upon to perform a sadder duty than that which we discharge by recording the foundering of Her Majesty's ship Captain, and the death of some 500 gallant men. The event is almost without a parallel, as regards the last hundred years, save that supplied by the sinking of the Royal George at Spithead. With the principal facts our readers are by this time thoroughly familiar. They have been very fully, and, for the most part, accurately, narrated in the columns of the daily press. It is impossible to put them more shortly or simply than they are stated in the following passage, which we extract from the "Times:"—

"Full details have now been received of this great misfortune. It occurred about 12.15 A.M. on the 7th inst., off Finisterre, the ship at the time being under double-reefed fore and main topsails, on the port tack, close hauled, with the wind about N.W. and very squally, with rain and heavy sea. About midnight the ship was felt making a very heavy roll to starboard, and before she had time to recover, a heavy sea struck her and threw her on her beam ends. She then turned bottom upwards, and eventually sank, going down stern first. From the time she fell on her beam ends to the time of sinking was about ten minutes. Captain Burgoyne and a few of the crew swam to the steam pinnace, which was floating bottom up; shortly afterwards the second launch passed close to the pinnace, and Mr. May, the gunner, and two men succeeded in getting on board, but Captain Burgoyne failed in the attempt. After various unsuccessful efforts to save him and others, they were so nearly swamped that they found themselves forced to bear up, or the launch must have gone from under them. At this time there were nineteen persons in the launch, but one man was washed out of the boat by her shipping a heavy sea, which nearly filled her. There was no sail in the boat, and only nine oars. Mr. May knew that land was dead to leeward of the ship, and at daybreak they sighted Cape Finisterre. At last the weather moderated, and they were able to land at Finisterre about noon on the 7th."

We have nothing to correct in the foregoing statement, nothing to add, except that steam was up at the time, but it does not appear that the engines were at work. Among those lost were Captain Coles and a son of the First Lord of the Admiralty. The death of the first gentleman is especially to be regretted by the advocates of the turret system; while that of the latter will, probably, do even more injury at present to a good cause. With Captain Burgoyne we have lost one of the most gallant and able young officers in the British navy; the only son of a man who has taken one of the highest possible places in

our profession. There is not an engineer who will not condole with Sir John Burgoyne on his bereavement. There are times, too, when technical knowledge is a direct source of regret to its possessor, and we confess that we wish we knew nothing about the internal arrangements of the "Captain" or any other steamship. Writers for the daily press have not had their souls harrowed by the picture which we cannot, do what we will, resist calling up of a scene presented by the stoke-hole of the ill-fated ship a few minutes before she sank. Her boilers were fired athwart ship, and the moment the vessel fell over on her beam ends the stoke-hole became a literal hell. The contents of the furnaces of the port boilers, now right over the unfortunate stokers, lying or standing on the starboard boiler fronts, must have forced the doors open by their weight, and poured in a fiery shower upon the men. The immediate destruction of the draught must have caused an irruption of flame and smoke which filled the stoke-hole; death by drowning came as a happy relief to wretches literary burning alive. No wonder that some of the survivors state that they heard the shrieks of the stokers above all the din of the storm. Such a death as the stokers of the "Captain" died falls happily to the lot of few shipwrecked men. It is none the less to be mourned over.

And now a question of prominent importance presents itself for consideration —Why did the "Captain" founder? Only a couple of weeks since we placed on record the fact that she has proved herself one of the fastest and stiffest ships under canvas in the Royal Navy. Yet a disaster has befallen her, the like of which never befell any modern ship of war. The fact will be explained by different men in different ways, but the prominent and all-pervading idea is, no doubt, that the ship had too little freeboard for stability; and a hasty condemnation will be passed on all turret ships as a consequence. We think it may be shown, however, that no deduction can be more illogical. Small freeboard is in itself no cause of instability. For example, it is possible to construct a raft of great width, capable of carrying a load quite as considerable as that on the deck of the "Captain," and with a freeboard of but a few inches, which it is impossible to overset. Stability—that is to say, the power of resisting a force tending to overturn a floating mass—depends, not only on freeboard, but on breadth of beam. We may reduce beam and increase freeboard, or reduce freeboard and increase beam with precisely the same result as far as stability, in the sense we have used the word, is concerned. The "Captain" had a freeboard of about 6 ft. 6 in. at the time of her loss. It was intended that she she should have had a freeboard about 21 in. greater, or, say, a little over 8 ft.; but by an error on the part of Messrs. Laird very similar to that committed by Mr. Reed in designing the "Bellerophon," the ship swam 21 in. deeper than she ought to have done. The chances are that this error led indirectly to the loss of the ship. We shall not now go into any elaborate disquisition of the question of stability and the principles which determine its amount in any given vessel. They have already been laid down in our columns. We shall simply deal with facts. We have been at the trouble to calculate the moment of stability of the "Captain," and we find that it progressively increased until the vessel heeled to about 15 deg. From that point it rapidly diminished. If the ship had floated higher in the water it is true that the centre of gravity would have been carried up; but the increase of freeboard would have more than compensated for the fact, and although we confess that we have only calculated the stability of the ship as she was, not as she was intended to be, we believe that she would have been much less likely to overset if she had been 8 ft. 3 in. out of the water instead of 6 ft. 6 in. The reports from the fleet state that for time before her loss the "Captain" was sailing close hauled, lying over at an angle of about 15 deg., and doing very well. But it is certain that at this angle her stability had reached its maximum, she had nothing whatever to spare. Then came a squall which "made the sea all white with foam." The ship heeled over still more under its influence. The angle of maximum stability was passed and we know the result. It has been urged that the pressure of the wind on the hurricane deck aided in preventing the righting of the hull but this is a fallacy to a very great extent indeed. There was, in the first place, a poop and forecastle, which increased the average freeboard, and so far deducted from the

influence of the wind on the hurricane deck. We have calculated the effective area of the remainder, and find that it was about two-thirds of that of the ship's main-topsail, and bearing in mind how close this area was to the water, and how small its leverage must have been, we cannot resist the conclusion that the hurricane deck had little or nothing to do with the catastrophe. There can be little doubt but that a careful inquiry into all the circumstances connected with the loss of the "Captain" will be carried out by the Admiralty at the first suitable moment; and until that inquiry is completed we do not care to express very decided opinions as to the immediate cause of the ship's loss, but we wish nevertheless to direct attention to one or two points. It must have been known at the Admiralty what was the ship's maximum angle of stability. Was Capt. Burgoyne in possession of the facts? Had he a diagram similar, we will say, to that contained in the paper on the Stability of Monitors, read on the 4th of April, 1868, by Mr. Reed, before the Institution of Naval Architects? If Capt. Burgoyne possessed such a diagram, he must have known that the moment the ship he commanded heeled 15 deg., she had reached her maximum limit of stability, and should have shortened sail. Our belief is, that neither Capt. Burgoyne, Capt. Coles, nor Messrs. Laird, really knew what was the maximum angle of stability of the ship. But the Admiralty either did know, or ought to have known, and, knowing, they should have imparted their information to the commanding officer of the ship. It may be urged that the Admiralty, as a rule—a very bad one, we may add—never do impart such information to commanding officers; but it must be borne in mind that the "Captain" was an exceptional ship, and that the Chief Constructor of the Navy had expressed very strong opinions about masting low freeboard vessels. In such a gale as was then blowing, it was not safe to carry more sail than would bear the ship down to about 8 deg., leaving 7 deg., or thereabouts, and about 2 ft. 6 in. of freeboard on the lee side of the ship, as a margin of safety. If, however, the Admiralty failed to supply all the requisite information to Capt. Burgoyne, they have been guilty of an error of judgment which has, directly or indirectly, led to the loss of the ship.

We have been already told that with the "Captain," masted monitors or low freeboard turret-ships disappear for ever. With this opinion we do not agree. We believe that, as we have already stated in a former article, the Government of this country would be very unwise if they built a second "Captain;" but we hold at the same time that the "Captain" upset, not because she was masted, but possibly because she was overmasted, possibly because she was injudiciously handled by an officer who did not and could not know all the merits and demerits of a strictly experimental ship. The "Captain" carried more sail for her size than any other iron-clad in the service, if the drawings of her rig which we possess are correct; and the putting of this enormous sail power into the ship was no doubt a fatal error on the part of Capt. Coles. But it does not follow because the "Captain" has gone to the bottom that it is impossible to mast a ship with a beam of 53 ft. —that of the "Captain"—and a freeboard of 8 ft. or 9 ft, in such a way that she will sail well enough to economize coal on all ordinary duty, and yet carry her sails with perfect safety in good hands knowing perfectly of what the ship is and is not capable.

It would but uselessly prolong this article to repeat here what we have repeatedly said as to the propriety of building ships which shall be monitors in action—ships with large freeboard at other times. It is possible, we believe, to design a ship with false bulwarks, which might be removed and thrown overboard, if necessary, in two hours, and yet very largely increase her freeboard at all other times. It is also possible to build a ship which, swimming 10 ft. or 11 ft. out of the water in ordinary service, could yet be sunk within 2 ft. of the water's edge, if need were, by taking in water ballast when going into action. On these points we shall not dwell now. It only remains to state that, in our opinion, the "Captain" was lost, not because she was masted, but because she was *over* masted; and secondly, because her commander did not know of what she was and was not capable.

The merits and demerits of turret ships remain to all intents and purposes practically unaffected, because there is not a competent naval man in the service

who did not know that the "Captain" was a very imperfect representative—good as she was—of the best possible iron-clad ship of war.

ON THE NATURAL LAWS OF MUSCULAR EXERTION.

By SAMUEL HAUGHTON:

From "Nature."

The experiments published by Mr. W. Stanley Jevons, in "Nature," on the 30th of June, last,* illustrate well two laws of muscular exertion which were established by experiments made by myself in 1862 and 1863. These laws may be thus stated:—

Law 1. The work given out by a single group of muscles, in a single contraction, is constant.

Law 2. When the same group of muscles is kept in constant action, the total work done by them until fatigue sets in, multiplied by the rate at which they are compelled to work, is constant.

Mr. Jevons' first series of experiments, in which different weights were thrown by the arm to various distances on level ground, illustrates the first law. In throwing weights in this manner, the arm, after a little practice, instinctively pitches the weight at the angle corresponding to the maximum range, and as the maximum range is proportional to the square of the velocity of projection, it may be used to replace that velocity squared, in estimating the work done by the arm.

The total work done is the same as if the weight used and the weight of the arm were concentrated at the centre of oscillation of the loaded arm, regarded as a compound pendulum.

Let us assume

w = weight held in hand;
x = weight of arm;
v = velocity of centre of oscillation.

By Law 1, the work done is constant and is represented by

$$(w + x)\, v^2 = \text{const.} \tag{1}$$

Let

V = velocity of hand;
l = radius of oscillation;
a = length of arm.

then

$$v = \mathrm{V}\,\frac{l}{a} \tag{2}$$

It is easy to show (assuming the arm to be a uniform cylinder) that

$$\frac{l}{a} = \frac{2}{3} \cdot \frac{(3\,w + x)}{(2\,w + x)} \tag{3}$$

By means of (2) and (3), equation (1) becomes

$$\frac{(w + x)\,(3\,w + x)^2}{(2\,w + x)^2} \times \mathrm{R} = \mathrm{A}; \tag{4}$$

where R denotes the range (proportional to V^2) and A denotes a constant, if Law 1 be true.

Mr. Jevons' experiments give the following corresponding values of w and R.

w.	R.
56 lbs.	1.84 ft.
28 "	3.70 "
14 "	6.86 "
7 "	10.56 "
4 "	14.61 "
2 "	18.65 "
1 "	23.05 "
½ "	27.15 "

We are required to assign certain values to x and A which will make equation (4) best coincide with the eight simultaneous values of w and R found by observation.

I find by trial that these values are

$$x = 8.1 \text{ lbs.}$$
$$\mathrm{A} = 262.2.$$

If we solve equation (4) for R, we find

$$\mathrm{R} = \frac{\mathrm{A}\,(2\,w + x)^2}{(w + x)\,(3\,w + x)^2} \tag{5}$$

Substituting for A and x in this equation their values above given, we can obtain by calculation the distances to which the weights should be thrown, according to Law 1.

We thus obtain the following comparison between theory and observation.

w.	R (observed).	R (calculated).	Difference.
56 lbs.	1.84 ft.	1.90 ft.	− 0.06 ft.
28 "	3.70 "	3 51 "	+ 0.19 "
14 "	6.86 "	6.06 "	+0.80 "
7 "	10.56 "	10.02 "	+0.54 "
4 "	14.61 "	13.90 "	+0.71 "
2 "	18.65 "	19.11 "	−0.46 "
1 "	23.05 "	23.85 "	−0.80 "
½ "	27.15 "	27.39 "	−0.24 "

The agreement here shown between observation and calculation founded on Law

* See September number of this magazine.

1, is quite as complete as the agreement between observation and the empirical formula used by Mr. Jevons, which may be written, in the notation of the present paper, as follows:

$$(2w + 7.8)\,R = 231.3. \qquad (6)$$

Mr. Jevons' third series of experiments consisted in holding various weights on the hand extended horizontally, and noting the time during which the weights could be so held.

The following are the weights and times observed:—

w.	t.
18 lbs.	14.8 secs.
14 "	32.5 "
10 "	60.3 "
7 "	87.4 "
4 "	147.9 "
2 "	218.9 "
1 "	321.2 "

Omitting the first of these experiments, I find that Law 2 satisfactorily accounts for the remaining six and gives a constant which is nearly identical with that obtained from my own experiments made in 1863.

When the arm is extended horizontally, if allowed to fall though an indefinitely small arc, the centre of oscillation falls like a free body under the influence of gravity, and the muscles then lift back the arm through the same arc, and this goes on continuously until the muscles are tired out.

Let us use the following notation:—

w and x are, as before, the weight held in the hand and the weight of the arm.

l = radius of oscillation ;
a = distance of centre of gravity of loaded arm from centre of shoulder joint;
δs = small space through which the centre of oscillation falls ;
n * = number of such falls during
t = whole time required to fatigue the muscles.

The total work done by the muscles in the time t, is evidently

$$(w + x)\,\frac{a}{l}\,n\,\delta\,s;$$

but $n\ \delta\ s$ varies as t, and therefore the total work done varies as

$$(w + x)\,\frac{a}{l}\,t.$$

The *rate* of work is evidently proportional to

$$(w + x)\,\frac{a}{l}$$

and since, by Law 2, the total work done before fatigue multiplied by the rate of work is constant, we obtain

$$(w + x)\,\frac{{}^2a^2}{l^2}\,t = \text{Const.} \qquad (7)$$

And since

$$\frac{a}{l} = \tfrac{3}{4}\cdot\frac{(2w + x)^2}{(w + x)\,(3w + x)}, \qquad (8)$$

we find by substitution,

$$\frac{(2w + x)^4}{(3w + x)^2}\,t = a. \qquad (9)$$

This equation (9) is the statement of Law 2, as applied to Mr. Jevons' experiments; and we are required to find values for x and a, which will make equation (9) best correspond with the given observations.

I find, by trial, that the following values will answer best :—

$$x = 7.4 \text{ lbs.}$$
$$a = 22{,}050.$$

If we solve question (9) for t, we find

$$t = A\,\frac{(3w + x)^2}{(2w + x)^4}. \qquad (10)$$

From this equation, substituting the values of x and A, we obtain the following comparison of observation and theory:

w	t (observed).	t)calculated)	Difference.
14 lbs.	32.5 secs.	34.2 secs.	− 1.7 secs.
10 "	60.3 "	54.7 "	+ 5.6 "
7 "	87.4 "	84.8 "	+ 2.6 "
4 "	147.9 "	147.6 "	+ 0 3 "
2 "	218.9 "	234.4 "	−15 5 "
1 "	321.2 "	305.5 "	+15.7 "

This comparison is very satisfactory, the difference being much less than possible errors of observations. Mr. Jevons' experiments further show that the *useful effect* has a maximum corresponding to a certain weight. This weight, which gives the maximum of useful effect, may be readily calculated from Law 2.

By equation (10), the useful effect is

$$w\,t = A\,.\,\frac{w\,(3w + x)^2}{(2w \times x)^4}. \qquad (11)$$

This will be a maximum, when

$$(2w + x)\,(9w + x) = 8w\,(3w + x);$$

or when

$$6w^2 - 3xw - x^2 = 0\,\cdot$$

or when

$$w = \frac{3 + \sqrt{33}}{13}\,x; \qquad (12)$$

* I have ascertained the number n from the acoustical observations made on the muscular *susurrus.*

or,

$$w = 0.73\,x.$$

Substituting for x its value 7.4 lbs., we find for the weight that gives the maximum useful effect,

$$w = 5.40 \text{ lbs.}$$

The useful effect observed by Mr. Jevons was as follows :

w.	Useful effect.
18 lbs.	266
14 "	455
10 "	603
7 "	612
4 "	592
2 "	438
1 "	321

The actual maximum corresponds to 5.4 lbs. lying between 7 lbs. and 4 lbs.

I may observe, in conclusion, that the difference of weights x of the arm, found in the two sets of experiments, is quite natural.

In the experiments in which the arm was held out horizontally, its weight 7.4 lbs., is the weight of the arm below the centre of the shoulder joint.

In the experiments in which the weights are thrown by the arm, a portion of the shoulder blade is in motion, in addition to the simple arm, and the total weight becomes 8.1 lbs.

MARINE ENGINES.

From "The Engineer."

The marine engine is undergoing just now a process precisely akin to that known in certain circles as a "revival." It underwent a similar process about ten years ago. It is the usual fate of revivals of all kinds that no lasting or permanent good comes of them. No good worth naming was done at the moment to steam navigation by the revival ten years ago. It remains to be seen whether the results of the revival of to-day will be more satisfactory. There is reason to hope that they will, because the enterprising practice of the engineers of to-day is based in a great measure on the experience afforded by the enterprising practice of engineers ten years ago, from which a great deal is to be learned. We enjoy advantages, therefore, which are peculiar to 1870, and had no existence in 1860. But the fact still remains, that experience alone will not teach any engineer how to effect improvements in marine engines. It will enable him to apply theory based upon fundamental natural laws to the best possible advantage, but it cannot compensate for a want of knowledge of these laws ; nor can it enable results to be obtained in direct opposition to them. So far, therefore, as improvements in marine engines now being introduced are based on sound theory, and applied with strict attention to the lessons of experience, are they likely to be successful but no further. It follows that the questions of paramount importance to the marine engineer are questions of the applicability of the teachings of theory in practice. The art of reconciling the two in the best way represents one of the very highest developments of engineering science. Now, it is certain that little, if anything, was done to improve the marine engine ten years ago which was not based on the soundest theoretical deductions. It is demonstrably right to expand steam as far as possible. It is scientifically correct to supply a boiler with distilled water instead of salt. No engineer—using the word in its highest sense—would object to the axiom that steam should be thoroughly dried by the evaporation of suspended particles of water before it finds its way to the cylinder. Nevertheless, when expansion, surface condensers, and superheaters came to be applied to the marine engine some ten or twelve years ago, it was found that they were one and all failures. There is no necessity for mincing matters. They all failed, and they all cost those who tried them heavy sums for their temerity. But they did not fail because they were intrinsically defective. They failed because they were used without experience. We will not say that expansion, and superheating, and surface condensation are now being re-introduced after a more or less prolonged abandonment, because they have always been in modified use since they were first introduced. But we can say with perfect truth that they are now being used by some engineers in a way which, although contemplated by their inventors or proposers, was not found to succeed

some years ago. Thus we have not only an increasing tendency to use higher pressures than were formerly found to answer, but we have that tendency developed into actual operation. The same thing may be said of high measures of expansion, quick piston speeds, and, perhaps, of superheating. If these things are used in certain ways we know that they will fail now, as they have done already, to constitute improvements in marine engineering. It remains to be seen whether a happier result can be obtained by using them in a somewhat different way, in the first place; and in the second place, whether this use in a different way will or will not impair their efficiency. The questions thus opened up deserve the most serious attention of all mechanical engineers, whether engaged in marine engine building or not, because the steam engine is common to all mechanical engineers and much that is true of the land engine will apply to the marine engine, and *vice versa*; so that the maker or designer of land engines may not only learn a great deal from the marine engineer, but impart a great deal of information in return. The best way of arriving at sound conclusions on any subject is to learn all that can be said about it by good authorities. It is to be regretted that shipowners and engineers have hitherto proved far more reticent on all that concerns their work, than the general public will easily believe. There must, no doubt, be a great mass of information floating about as to the construction and working of the best marine engines and boilers which has never yet seen the light, in the shape of paper, discussion, books, or even pamphlets. Perhaps, one of these days a lot of it will be all collected and published, and the scientific world will then be in possession of what is sadly wanted, a thoroughly good work on the marine engine. Meanwhile we hail with no little satisfaction the publication, however limited, of any practical paper on steamship economy dealing with questions concerning it as things are, not as things were; and we find just such a paper in the twenty-ninth volume of the "Transanctions of the Institution of Civil Engineers," in the shape of a paper "on Ocean Steam Navigation," read by Mr. John Grantham, C. E., last December, and the discussion which followed it. Paper and discussion are alike full of valuable information. We are very sorry that they are not generally accessible. An attempt to abstract Mr. Grantham's paper, or the discussion which followed it, would do scant justice to both; but there are certain lessons conveyed which are highly instructive on several points, and admit of reproduction here.

One of the most important facts to be borne in mind in dealing with the subject of steamship economy is, that the ship which performs a given voyage with the smallest expenditure of fuel and the largest paying load, is, to all intents and purposes, the best ship that can be got. It is a mistake, however, to jump to the conclusion that the ship whose engines use the least coal must of necessity make the cheapest voyages. More, very much more, depends on the ship and the method of propulsion adopted than upon the engines. Thus, by merely cutting a ship in two, and lengthening her some 30 ft. or 40 ft., her paying cargo capacity has been doubled without in any way affecting the cost of propulsion or prolonging the duration of her voyage. The engineer when speaking to the shipowner, seldom hears much about consumption of coal per indicated horse-power, but he hears a great deal indeed about the consumption per voyage. Economy of fuel per horse-power is one means to the desirable end; but it is not everything, and we lay considerable stress on this fact, because there is no doubt that eminently economical engines, from being improperly put to work in badly designed boats, have completely failed to give satisfaction; the cost of such engines per voyage being considerably in excess of the cost of much worse engines placed in better boats and working under more favorable circumstances. The engines have been deemed the culprits, and really valuable improvements have been hastily condemned as failures. The existence of this truth was evidently fully recognized by both Mr. Grantham and his hearers, but there was not so much said on the subject as was desirable. All the speakers were agreed, however, that great length, in proportion to beam, was absolutely essential to economy. The truth of the proposition is demonstrated by the practice of the best builders of the day.

Although steam-engine economy does not alone secure steamship economy, it conduces powerfully to that desired end;

and it was to be expected that, considering many of the circumstances under which the paper was read, not a few instances of extraordinary economy of fuel would have been cited. The high character of the Institution, however, no doubt operated beneficially, and not a single speaker ventured even to hint at the wonderful tales sometimes told before less eminent societies, and less able judges of their truth or falsehood. On the contrary, the meeting evinced a general tendency to disbelieve in any statements of excessive economy. The advocates of the compound engine one and all spoke of the system, we were pleased to find, in much the same qualified terms of praise as we have ourselves bestowed on the principle of combination when applied to marine purposes. We especially commend to attention the opinions expressed by one of the speakers, himself a member of one of the largest and most enterprising firms of shipowners in the kingdom. He stated that he had given a great deal of attention to the question of steam navigation, more especially to the indicated horse-power developed at sea, and had come to the conclusion that shipowners greatly overestimated the power actually evolved, and consequently underestimated the consumption of fuel. On this point we have long held similar opinions, as in no other way can the extraordinary results said to have been attained, under certain circumstances, be accounted for. The speaker stated that from the best returns he could get he had arrived at the conclusion that in most of the steamers which performed their voyages at high speeds the consumption was $2\frac{3}{4}$ lbs. of coal per indicated horse-power per hour, and it was not till the speed was reduced to $8\frac{1}{2}$ or 9 knots per hour that a consumption of $2\frac{1}{2}$ lbs. was reached. It is quite possible that such a statement will be disputed, and it is, therefore, well to place before our readers figures either given by Mr. Grantham or by his hearers, bearing on the question. The Rakaia, built by Messrs. Randolph, Elder, and Co., for the Colonial Steam Navigation Company, of New Zealand, is 265 ft. long, 34 ft. beam; draught, loaded, 21 ft. Her engines are compound, the two large cylinders being 87 in., and the two smaller cylinders 43 in. diameter, by 4 ft. 3 in. stroke, geared; 27 revolutions of engines per minute to 67 of screw. The consumption of fuel is taken by Mr. Grantham to be 2.13 lbs. of coal per horse per hour, but he does not give the indicated horse-power as more than an assumption. The Somersetshire, one of Messrs. Wigram's ships, burned, at a low speed, 2.36 lbs. per indicated horse-power with ordinary engines, 20 lbs. steam, surface condenser and superheater, indicated power 650-horses, displacement about 3,900 tons. Mr. Stephenson spoke of a steamship which, on her first voyage to China and back, burned only 2 lbs. per indicated horse-power. Mr. Ravenhill stated that the consumption of fuel by the engines of the Peninsular and Oriental Company averaged 2.4 lbs. to 2.5 lbs. per indicated horse-power per hour. These are nearly, if not quite, all the instances in which the consumption per horse-power was cited. And although there are dozens of figures giving the total consumption per day, the speakers either could not or would not give the indicated horse-power. Mr. Bramwell gave an admirable example of the way in which inaccurate statements concerning economy of fuel at sea are put in circulation. The example was supplied by Mr. Grantham himself. That gentleman stated in the course of his paper that the Peru, a vessel fitted with compound engines of 350-horse power nominal, worked in running light from Glasgow to Liverpool up to 1,400-horse power indicated, her speed being 14 knots; the consumption of fuel not stated. He then went on to say that the Peru took in cargo, and the result of a voyage into the Pacific and back was that she burned 24 tons 1 cwt. of coal per day, which, using 1,400 as a divisor, Mr. Grantham took to represent 2 lbs. per horse per hour. But instead of the revolutions of the engines being the same as on her first trip when light, they corresponded to a speed of but 9-8 knots, which should be obtained with 410-horse power if the draught remained unaltered. But even allowing for the cargo, it was quite certain that nothing like 1,400-horse power was regularly developed, and the consumption was, therefore, more properly 4 lbs. per horse than 2 lbs. When we find careful, impartial authorities like Mr. Grantham falling into such a fallacious mode of reasoning as this, what can we expect of men who, however honest, cannot well help deceiving themselves? Not a single instance has ever come under our knowledge in which

a complete and accurate set of diagrams has been taken over a series of years in any marine engine-room, without proving that not only is the power developed overrated almost from the first, but that it goes on decreasing to the end as the boilers become foul or worn out. A chance indicator diagram, taken, say, once in a watch, when the pressure of steam is highest, and the engines doing best, is, as a rule, taken to represent the power exerted on the average during a whole voyage, not the slightest allusion being made to the pulling up of the engines by a head wind or a heavy sea. It is to the last degree desirable that makers of eminently economical engines should take the trouble of producing for the benefit of the scientific world the most complete statements of the indicated horse-power of the engine on long voyages. When they refuse to do this it is safe to assume that the conclusions of the users are based on insufficient data.

We have said so much concerning current evidence of economy in marine engines that we have not left ourselves space to deal at present with many other interesting features of Mr. Grantham's paper. After all, we are disposed to doubt the existance of any matter of more importance connected with steam-engine economy than the basis on which statements of engine builders and shipowners concerning certain types of machinery rest. When it is borne in mind that a difference of 0.1 lb. of coal per horse per hour will, in the case of steamships plying between England and the United States,represent a saving of £2,000 a year to the owners for a weekly service each way, it will be seen how important it is that the public should be placed in possession of not only the most complete but the most reliable information. Whether it is or is not possible to ascertain with some degree of certainty exactly what the indicated horse-power exerted throughout a long voyage is, we are not prepared to say; but it is quite clear that until such evidence is placed before us all statements concerning abnormally small consumptions of fuel must be looked on by sensible men with extreme doubt.

MODERN FIRE-ARMS—THE MARTINI-HENRY RIFLE.

From "The Engineer."

A report has just been issued by the committee appointed to settle the question of the new rifle for our army, which contains an analysis of the results of the trials of the 200 experimental arms issued to various regiments at home and abroad, and also to H.M. SS. Excellent and Cambridge, and the School of Musketry at Hythe. When these rifles were issued they were accompanied by a series of questions, which, after a considerable interval, during which the arms were put through various tests, were returned answered to the committee. These answers, with remarks by the committee, form the material of the Blue Book now before us.

The first point which it was desired should be cleared up was whether the rifle, as a whole, was more than ordinarily liable to injury, and here the reply appears to be most decidedly no. One or two casualties have occurred, the chief of which was the fracture of a tumbler, and nearly all arose from the use of faulty metal. None of them were peculiar to the construction of the arm, and each might have arisen with any other.

Difficulty in loading has occasionally arisen from the following causes :—Firstly, cartridges becoming bent ; secondly, cartridges defective in minor details of manufacture ; and, thirdly, the sharp edges of the chamber causing the paper covering to ruck up. In the majority of cases the extractor has worked satisfactorily, and where it has failed to do so allowances must be made for the want of experience on the part of the men using the arms. The motion of extracting in the Martini-Henry is so different from that in the Snider, that it is only natural to expect a little awkardness at first.

Many of these experimental arms have been severely tried by exposure to weather, and have not been found wanting. In one case they were piled in the open air, without cleaning for eight days, and were still perfectly serviceable. With regard

to the coil spring, the general tendency of the reports goes to prove that many of the springs that were issued were too weak, and that most of the missfires were attributable to this cause. M. Martini employs a spring of 40 lbs., though he nevertheless thinks that one of 33 lbs. will be sufficiently strong ; but the springs of the rifles sent out from Enfield appear to have been of 26 lbs. only. The committee have, therefore, decided that in future the springs shall be made of the strength approved by M. Martini. From a calculation of the average number of missfires when eighty-six rifles were fired with the weak springs, and when the same rifles were fired with the stronger springs, we find that, with the weak springs, 163,277 rounds of ball and blank were fired with 3,814 missfires, showing a percentage of 2.34 ; but with the strong springs 26,463 rounds of ball and blank, missfires had been fired with only nine or a percentage of .034.

No objection is urged against this sudden extraction of the empty cartridge case, since it can, if desired, be easily controlled by opening the breech gradually, which is found to be an advantage in extracting a loaded cartridge. The divided stock has been found satisfactory with two exceptions, in which the butts are reported loose. One of these exceptions is rifle No. 100 at Quebec, which is constantly turning up under the various heads as a shortcomer, so we can fairly suppose it as having been a carelessly made arm. The reports as to recoil are somewhat contradictory, but we do not infer that it is excessive, though probably greater than that of the Snider. The Royal Engineers consider that it is too heavy a rifle for their wants; but the remainder of the reporters are of opinion that it is not unwieldy, at all events for ordinary men, though it might be "for some of the puny recruits now passed into the service." The back sight might be improved both in position and construction. In its present position, though well placed for sight, it interferes with the hand at the trail. The committee recommend the adoption of a flat sliding bar with three platinum lines, one long in the centre, and two shorter equally dividing the space on either side. They also recommend the addition of a platinum wire at the centre of the V, at the end of the flap. The sword-bayonet, which, it will be remembered, is a saw for a portion of its length on one side, is generally approved both as a weapon and as an implement of service. It is suggested that a few more teeth be added, to which the committee see no objection. A few complaints have been made that the weight of the sword when fixed detracts considerably from the accuracy of fire; but when it is borne in mind that the sword will only be fixed when troops come to close quarters, and when, consequently, accuracy of fire ceases to be unnecessary, the objection disappears. The fittings, so to speak, of the rifles, such as the cleaning apparatus and muzzle stopper, have also been reported upon ; and we find that, on the whole, it seems desirable to retain them with trifling alterations. The tendency of the cleaning rod to come unscrewed is complained of, and some different means of securing it is necessary. Possibly a spring catch would be found to fulfil all requirements, and it would certainly be pleasanter to use.

So much of the reports as concerns the ammunition is very satisfactory. The evidence, as a whole, points to the advantage of a shorter cartridge, which, we are happy to say, has been provisionally adopted. The escape of gas from the base of the cartridge has been often noticed in the early use of the Snider rifle, and was found to arise from the cutting of the base cups against the rim of the chamber in rifles where the breech-block was too short. In the present trials, out of 137,308 rounds, only seven ball cartridges have been cut at the base, a very satisfactory proof of the excellence of the ammunition.

Generally, then, the opinion formed after the use of the experimental arms appears to be eminently favorable. The men are said to be greatly pleased with the weapon, and consider it far superior to the Snider. The rapidity of loading is found to be more than double that of the Snider, and the accuracy of shooting is much greater, the allowance for wind being considerably less. There seems to be no tendency to foul after continuous firing, and the manipulation of the breech is easy, simple, and safe. The arm is, however, generally objected to as too long, and the committee think also that a rifle of the same length as that in use by the Rifle Brigade and 60th Rifles would be more serviceable. There are objections

to a short rifle—for instance, in firing in two ranks standing; but the objections do not outweigh or even balance the advantages. The whole of the arms upon which the reports alluded to are based were hand-made, and consequently were not perfect or uniform. Many of the casualties mentioned in reply to the first question put by the committee are most probably due to this cause, and many of the missfires are explainable in the same way, through the strikers being too short. Where any difficulty in loading was experienced it was traceable to the long cartridges. As has been already mentioned, a shorter "bottle-necked" cartridge, without paper covering, will probably be finally adopted, and then, of course, the breech mechanism will also be proportionately shorter; so that when these alterations are carried out we shall be in possession of a breech-loader which it will be extremely hard to beat.

After wading through this and other blue-books, and reports relating to the Martini-Henry rifle, the question naturally arises—When shall we see it in use? It is now more than a year since the Martini-Henry was finally reported to be superior to the Snider, and yet we do not really seem to be much nearer the end than we were then. The committee are now engaged on the short-mechanism pattern, and we see that a new bayonet of Lord Elcho's design is to have a trial. Must we wait another year before anything is absolutely decided, and yet another before rifles are made in quantity sufficient to arm our troops? The position of the country under the present circumstances demands that the army shall be placed in the best possible state of efficiency. What prospect have we of the attainment of this desirable end as far as rifles are concerned? The regular troops and part of the militia have Sniders; the remainder of the militia and the volunteers have a weapon admittedly worthless, and it is said that we have 300,000 more Sniders in store. For the last three years we have been experimenting with the view of finding a substitute for the Snider, and now we can only hope to get it when the war is over, or, perhaps, when it is too late. Meanwhile the War Department is motionless, and our 300,000 Sniders remain in the galleries of the Tower and elsewhere—a magnificent but useless show.

SOME CHARACTERISTICS OF MODERN FIRE-ARMS.

As events thicken on the area of passing strife, many theories in respect to military fire-arms are tested by inexorable practice. Speculations as to the relative superiority or inferiority of fire-arms are narrowing themselves into the category of proven facts. At the commencement of this war both artillery and small arms had entered upon new phases; but it was in respect to military small arms chiefly that the greatest difference of opinion existed or was assumed to exist.

Speaking for ourselves, we never were of opinion that any slight shade of difference in the purely mechanical superiority of the Chassepot over the needle-gun, or the latter over the Chassepot, would count for so much as zealous advocates and partisans on either side expected. We have been in the habit of thinking little of the fact that the effective range of the French small arm is greater than that of the Prussians, or that the wounds inflicted by the Chassepot are more ragged and deadly in character. At any period before the breaking out of this war we should have been perfectly willing to concede that the Zundnadelgewehr is—taken all in all—a more imperfect mechanical strument than the Chassepot, which latter, however, has many defective points. Conceding all this, there was no time at which we should have been averse to credit the Prussians by anticipation with much of the success as marksmen that they have since achieved; our reasons for this belief mainly hinging on the fact, too often forgotten, that in a mechanical point of view an arm and its ammunition are not all in all. The physique and temperament of the shooter are items in the mechanical account—the soldier being to all practical intents an integral part of the machine.

This view has been amply borne out in all the contests which have occurred between French and Prussians up to the time when these remarks were made. It has been proved that the French temperament, by its impetuosity, its mobility, its desire to be doing something, has proved itself very much at a disadvantage in all that concerns the successful management of a military breech-loading small arm. Even in the old days of muzzle-loading, the great difficulty in action was to supply cartridges with due rapidity, many

instances having occurred in which soldiers have had to elect between injudicious bayonet charge or absolute retreat, merely because their ammunition had given out. This being the fact, it always seemed to us that two of the very advantages claimed by the French for the Chassepot over the needle-gun, namely, its longer range and its greater rapidity of deliverin fire, might turn out absolute disadvantages in the field. So far as events have gone, and can be accurately taken count of, this has absolutely seemed to have been the case. At the battle of Forbach groups of French infantry were seen making their way in disorder to the rear, merely because their ammunition had been all fired away; and subsequently at Worth, MacMahon complained that his infantry had not been able to keep themselves supplied with ammunition in the contest.

Coming next to the mitrailleuse, it does seem wholly inexplicable, and not more inexplicable than ridiculous, that the French should have affected so much mystery in respect to a weapon that, whether good, bad, or indifferent, presents such obvious indications of constructive points to be carried out into practice, and which could have been executed in many different ways. The French Emperor, as most of us know, once wrote a folio book on artillery and fire-arms generally. His Majesty has ever since manifested a certain amateur predilection for this branch of the service; but if, as would appear from published accounts, he has had anything to do with placing the mitrailleuse in the rank of an artillery instead of an infantry weapon, then we think his inspirations have led him very much astray. In some respects an instrument on the principle of the mitrailleuse has important functions and capabilities—perhaps we should rather say it is a machine that makes important promises, but we should have imagined that some of the most obvious considerations of what modern field artillery is expected to do would have led mitrailleuse constructors to determine its place as an infantry weapon from the first. By infantry weapon we mean that, although necessitating a service of its own, the mitrailleuse, its genius and construction regarded, should emulate small arms rather than artillery, if it would hope to give a good account of itself. In the present day field artillery is not worthy of the name if it does not embrace, or has not the faculty of embracing shell practice. Obviously no mitrailleuse light enough to take part in field evolutions could be endowed with that faculty to any but a limited extent. Weight and cumbrousness would be against it if made large enough for shell practice, and even were increased weight no longer a consideration it would still be undesirable to project shell in such a salvo from such a machine. We English have, no doubt, placed the mitrailleuse in its true prospective rank. Recent experiments at Shoeburyness have proved that it can advance no pretensions to rank as an artillery weapon; that it is especially an infantry weapon; and, further, that to be effective the mitrailleuse should be able to employ the ordinary small arm service cartridge, of whatever description that may be. Here we must observe that the ordinary compound cartridge of the British service—the Boxer cartridge—does not appear to answer well for mitrailleuse purposes.

Relative to the barrel construction of the mitrailleuse, we have heard even mechanicians wonder why the expedient of aggregating 37 hexagonal barrels in a circumscribing case of wrought iron is resorted to, when, as seems to them, the much more simple expedient of boring 37 barrels out of a block of steel is at hand. If a mechanician, clever as he may be, would only try his hand at making a mitrailleuse in such fashion, his eyes might, perhaps, be opened and his opinion might alter. Some years ago Sir Joseph Whitworth, relying on accurate machinery, thought he could make double-barrelled fowling-pieces by boring two holes out of an elongated steel block. He found himself mistaken, as anybody would find himself mistaken who should make a similar attempt.

In the present contest between French and Prussians, artillery on either side has played a conspicuous part, but hitherto no sufficient intelligence has come to hand of the practice of the artillery employed. Hereafter we shall doubtless know, though at present we do not know, the relative value as now exemplified of howitzers and long field-guns in shell practice, and some light will be thrown on the specialties of shell fuses, both French and Prussian. Looking at our own artillery, it is quite clear that the segment Armstrong shell

and its mechanical fuse are both—to speak plainly—a failure. The result of practice at Dartmoor last year went to prove, amongst other things, that the Armstrong segment shell was next to useless against earthwork, and as against troops in the open field so much inferior to howitzer shrapnel that ordnance and ordnance material of this sort would be mainly relied upon should we, by force of events, be seriously engaged on an European field of battle.

STATISTICS OF AMERICAN IRON MANUFACTURE.

We take from the columns of the "Protectionist" the following extract from the forthcoming report of the Secretary of the American Iron and Steel Association :

BLAST FURNACE STATISTICS.

The development of the pig-iron manufacture that was noticed at length in our report for the years 1866, 1867, and 1868, continued with increased vigor during the year 1869. The remarkable growth of this branch of business during the past few years has, by no means, been confined to the older iron regions, from which, until recently, the principal supply of iron for the whole country has been drawn. Localities that have long been known as admirably adapted to the manufacture of iron, but which it has been supposed would not be called upon to yield their stores of mineral wealth for years to come, have suddenly loomed up into importance. Several States that five years ago were compelled to purchase every pound of pig-iron for consumption, now produce many thousands of tons annually. For some years prior to 1860, Indiana produced a small quantity of charcoal pig-iron, about 1000 tons per annum. From that time until 1867, no pig-iron of any kind was made in the State. In 1867 a large bituminous coal furnace, with a capacity of 9000 tons per annum, and employing a capital of $150,000, was erected at Brazil, Clay county. In the following year two furnaces were built, with a capacity of 7500 tons each, with a capital of $200,000. The same year another furnace was built in Clay county, with a capacity of 3600 tons, and employing a capital of $100,000.

Last year a fifth furnace was blown in in the same locality, having a capacity of 3600 tons and a capital of $125,000. A sixth furnace, at Terre Haute, has just been completed, having a capacity of 7500 tons, and employing a capital of $150,000. These furnaces produced, in 1869, about 23,500 net tons of iron. Their united capacities are 35,000 tons per annum, and a capital of $725,000 is employed in their operation. Four additional furnaces would have been erected during the course of the present year but for fear of legislation adverse to the iron interest. In Illinois, prior to 1859, a few hundred tons of pig-iron was made annually. From that time to the beginning of last year there was not an active furnace in the State. Within the past eighteen months, however, the business has received a new impetus. Six large stone-coal furnaces have been erected ; four of these are in the vicinity of Chicago, and two at Grand Tower, in Jackson county, on the Mississippi river. We hear of a seventh in course of construction, but cannot now name the locality. Thus, in the short space of eighteen months, Illinois has acquired a capacity for producing from 50,000 to 60,000 tons of pig-iron. A bituminous coal furnace, having a capacity of 35 tons per day, has been erected at Milwaukee, Wisconsin. Five large stone-coal furnaces have been built in Missouri within the past year. That great and growing State has now a capacity of 300 tons of pig-iron per day, with means for greatly increasing the production should legislation be propitious.

To show the condition of the iron manufacture in Eastern Kentucky, we can do no better than quote from a letter recently received from a gentleman living near Ashland, in that State. He says : "During the last three years, two large stone-coal furnaces and two charcoal furnaces have been built near this place, all within sight of each other, on the bank of the Ohio river. Raccoon, Buffalo, Lovel, Greenup, and Kenton furnaces, that were all idle during the depression before the war, have started again within three years, and, if Congress will let our tariff alone, two additional stone-coal furnaces

will be built near this place during the present year. The Lexington and Big Sandy Railroad is now in a fair way to be finished, opening up a vast ore and coal region, in which many new furnaces could be erected. The Kentucky Improvement Company propose to build or extend their road 30 miles, to a large deposit of ore, opening up a great charcoal section, and transporting ore to the river for sale and to smelt in furnaces which they propose to build. It is easy to see how a depression in business would affect these enterprises. The furnaces would not be completed, the roads would not be built, and the region of country, 125 miles long and 75 wide, now a wilderness, would remain as it is. Let prosperity be guaranteed to us by an adequate tariff, and what a change we would see—furnaces every few miles, giving employment to a hardy, industrious people; this whole section changed from a hunter's wilderness to the most wealthy and valuable part of the State."

In several of the Southern States, where before the war a few hundred tons of iron only were made in forge fires, companies are being formed and capital raised for the purpose of converting their beds of coal and of pure and rich ores into the many products required by a growing diversity of interests. Many of the present most active champions of home labor came from that section of our country.

ANTHRACITE IRON STATISTICS.

In the States north and east of Pennsylvania, the production of anthracite iron in 1869 was 269,256 tons, as follows:

	Tons.
New Jersey	54,201
New York	210,855
Massachusetts	4,200

The production of anthracite iron in these States has arisen from 64,969 tons in 1864, to the quantity above given in 1869. The anthracite furnaces in the States above named were erected as follows: 1 in 1844, 2 in 1845, 3 in 1847, 2 in 1848, 3 in 1850, 3 in 1852, 3 in 1853, 4 in 1854, 1 in 1855, 2 in 1857, 2 in 1860, 3 in 1861, 1 in 1862, 3 in 1864, 2 in 1865, and 8 since 1865; 8 of the whole number have been abandoned and dismantled.

The following statement shows the progress of this branch of manufacture in the States above named:

Years.	Mass.	New York.	New Jersey.	Total.
1854	4,978	35,619	24,372	64,969
1855	7,181	49,728	31,754	88,663
1856	3,855	52,826	29,247	85,928
1857	3,900	46,486	22,785	73,171
1858	3,000	49,380	16,447	68,827
1859	1,000	68,281	28,394	97,686
1860	——	79,509	27,092	106,601
1861	——	66,793	24,000	90,793
1862	——	72,702	27,500	100,202
1863	——	109,992	38,000	147,992
1864	2,509	121,863	41,000	162,863
1865	3,000	80,420	16,195	99,615
1866	3,606	118,274	40,680	162,560
1867	3,500	151,586	36,919	192,005
1868	4,000	160,681	47,209	211,890
1869	4,200	210,855	54,201	269,256

The production of anthracite pig-iron in Pennsylvania in 1869, was 692,739 tons. Of this quantity, 300,916 tons was made in the Lehigh region; 150,409 tons in the Schuylkill region; 123,273 tons in the Upper Susquehanna; and 118,141 tons in the Lower Susquehanna. This product exceeds, by 20,784 tons, or 3.09 per cent., that of 1868; 98,469 tons, or 14 per cent., that of 1867; 118,980 tons, or 20⅔ per cent., that of 1866.

This branch of manufacture exhibits the greatest growth on the Lehigh, and the least on the Susquehanna. Within the past three years 14 furnaces have been erected in the first-named locality, including two or three nearly completed, increasing its capacity about 140,000 tons. The product of the older furnaces has been increased materially by new appliances, enlargements, etc. In the Schuylkill region, the average annual increase for the past six years has been 16⅔ per cent. The capacity of this region may be set down at fully 180,000 tons.

The following statement shows the whole product of anthracite pig-iron for the past eight years:

Years.	Tons.	Years.	Tons.
1862	370,304	1866	573,750
1863	433,072	1867	594,270
1864	519,690	1868	671,955
1865	377,433	1869	692,730

The production in Maryland for 1869 of anthracite pig-iron was 9,155 tons.

The total product of anthracite pig-iron in the United States in 1869, is thus shown to be as follows:

	Tons.
Massachusetts	4,200
New York	210,855
New Jersey	54,201
Pennsylvania	692,739
Maryland	9.255
Total	971,150

The yearly product of anthracite iron for the past 10 years has been as follows :

Years.	Production. Tons.		Incr. or Decr. Per cent.
1860........	519,211		
1861........	409,229	....	decr. 21.18
1862	470,315	....	incr. 14.90
1863........	577,638	....	incr. 22.82
1864........	684,018	....	incr. 18 41
1865........	479,558	....	decr. 29.89
1866	749,367	....	incr. 56.26
1867........	798,638	....	incr. 6.57
1868........	893,000	....	incr. 11 80
1869........	971,150	....	incr. 8.75

RAW BITUMINOUS COAL AND COKE IRON.

The production in 1869 amounted to 553,341 tons, an increase of 213,341 tons, or 62.74 per cent. over that of 1868, and 235,694 tons, or 73.65 per cent. over that of 1867, and 284,345 tons, or 105.7 per cent. over 1866. In 1854 the production of this class of iron was 54,485 tons, since which the annual average increase has been 54½ per cent.

There was great progress made by this class of business in several localities during the past few years ; in illustration of this we will cite a few instances.

In 1864 there were eleven furnaces of this class in the Shenango Valley, Pennsylvania, the oldest of which was erected in 1844. The capacity of these furnaces was about 45,000 tons annually. During the five following years, to 1869 inclusive, there were erected in that locality ten additional stone-coal furnaces, having a capacity of from 85,000 to 95,000 tons, and employing a capital of $800,000. During the same time, three charcoal furnaces were built in the valley, with a capacity of 8,000 tons, costing about $50,000. The capacity of the old furnaces has been increased fully 25 per cent. by reversion and enlargement during the past five years. In the Hanging Rock region of Ohio, five bituminous coal furnaces have been built or rebuilt within three years, increasing the capacity of that region 40,000 tons per annum. These new furnaces employ a capital in works and ore and coal lands of over one million of dollars. A similar development in the charcoal manufacture has taken place in the same locality. In the Mahoning region, in Northeastern Ohio, twelve new bituminous coal furnaces have been built within three years ; four were blown in in 1867, five in 1868, and three in 1869. These new furnaces have an annual capacity of 95,000 tons, and cost $750,000. Two large bituminous furnaces have recently been erected in Michigan, one in the vicinity of Detroit, the other in the upper Peninsula—the latter, according to the latest advices, is about to be blown in. Of the growth of this branch of the pig-iron manufacture in Indiana, Illinois, and Missouri, we have frequently spoken.

CHARCOAL IRON.

The production of charcoal iron in 1869 amounted to 392,150 tons, as follows :

	Tons.
New England States......................	38,000
New York, New Jersey, Penn'a, and Md. .	134,000
Western States.........................	206,500
Southern States	13,650

This quantity exceeds by 22,150 tons, or about 6 per cent., the product of 1868; 47,809 tons, or 13.88 per cent. that of 1867, and 59,570 tons, or 17.91 per cent. that of 1866.

The annual production of charcoal pig-iron in the United States for many years past has been quite variable, as the following statement will show:

Years.	Production. Tons.		Incr. or Decr. Per cent.
1854........	342,298	....	
1855........	339,922	....	decr. 7.10
1856	370,470	....	incr. 9
1857........	330,321	....	decr. 10½
1858	285,315	....	decr. 13½
1859........	284,041	....	decr. 4.10
1860........	278.331	....	decr. 2
1861	195,278	....	decr. 29
1862........	186,660	....	decr. 4
1863........	212,005	....	incr. 13
1864	241,753	...	incr. 14
1865........	241,853	....	incr. 14
1866........	332,580	....	incr. 26½
1867........	344,341	....	incr. 3
1868......	370,000	....	incr. 7
1869........	292,150	....	incr. 5

It will thus be seen that, with the exception of a single year, there was a steady falling off in the production of charcoal iron from 1854 to 1862 inclusive, and as steady an increase from 1862 to the present time.

While but little progress has been made in this branch of manufacture in the New England and Middle States during the past three years, its growth in the West has been exceedingly gratifying.

Within that period a number of furnaces have been built in Ohio, largely increasing the capacity of that State for making this kind of iron. In Michigan 6 new charcoal furnaces have blown in, having a total capacity of between 30,000 and 40,000 tons. In Wisconsin, a new

charcoal furnace was put in blast in 1869, another has been blown in since the beginning of the present year, and a third is now in process of construction. Two new furnaces using charcoal for fuel have been built in Missouri and several in Kentucky. In the Southern States a number of old charcoal furnaces that went out of blast when the war ended, have recently been repaired and lighted. They are located as follows: One near Lincolnton, N. C., making about 1,500 tons per annum, a considerable part of which is converted into hollow ware and other light castings for local consumption. Two in Cass County, Georgia, which made, in 1869, 487 tons of charcoal iron, most of which was also made into hollow ware. Three in Alabama, which made respectively 500 tons, four, 908 tons, and one, 756 tons. The last-named State is making a great effort to develop her mineral resources. The late Legislature passed an act granting aid to several important railroad companies, upon the condition that in the construction and equipment of said roads preference must be given, terms being equally favorable, "in all contracts for cross ties, rails, chairs, spikes, joint fastenings, locomotives, cars of all kinds, and other materials and equipments, to the proprietors of such foundries, mills, manufactories and other works, as are engaged in the manufacture of iron, of ores, and of other raw materials found in the limits of the State of Alabama."

TOTAL PRODUCT OF PIG-IRON OF ALL KINDS IN THE UNITED STATES IN 1869.

Tons	1,916,641

As follows:

Anthracite pig-iron,	971,160
Raw bituminous coal and coke pig-iron,	553,341
Charcoal pig-iron	392,150

The product in 1865 was 931,000 tons, it having more than doubled in four years. This enormous increase in the production is due in a great measure to the operation of a protective tariff, and the noble response of this industry to the requirements of the country overthrows some of the most plausible theories of free trade.

ROLLING MILL STATISTICS.

The production of the rail mills for 1869 was as follows:

	Tons of 2,000 lbs.
Massachusetts	32,238
New York	79,463
Pennsylvania	319,653
Maryland	27,328
Ohio	41,837
Kentucky	7,817
Michigan	6,885
Illinois	53,261
Wisconsin	8,680
Other States	16,424
Total	593,586

The progress of this branch of manufacture during the past ten years is shown by the following table:

1869..205,038 tons of 2,000 lbs.					
1861..189,818	"	" Decrease,		7.4	p. cent.
1862..213,913	"	" Increase,		12.5	"
1863 175,703	"	"	"	28.9	"
1864..335,369	"	"	"	21.6	"
1865..356,292	"	"	"	6.2	"
1866..430,778	"	"	"	20.9	"
1867..462,108	"	"	"	7.3	"
1868. 506,714	"	"	"	9.6	"
1869..593,586	"	"	"	18.12	"

IMPORTATION OF RAILS.

During 1869, we imported from Great Britain 336,500 tons of rails, an increase of 36,340 tons as compared with the imports of 1868, 151,459 tons over 1867, and 216,622 tons over 1866. As we imported a few rails from other European countries, the total importation probably amounted to 345,000 tons, making, with the 593,586 tons manufactured here, a total consumption of 938,586 tons. Taking into consideration the growth of our railroad system, the requirements of the country for the coming five years will doubtless average over a million tons per annum. Of the product of rails for 1869, 9650 tons were Bessemer steel. The erection of one or two large rail mills is in contemplation, which will increase the capacity of our works beyond the total consumption of rails last year.

PRODUCT OF ROLLING MILLS OTHER THAN RAILS,

for 1869, was 642,420 tons, which may be divided as follows:

	Tons.
Merchant bar and rod	292,500
Sheet	36,320
Plate	68,000
Hoop	17,200
Nails and spikes	146,400
Axles and other	72,000

Of these manufactures we imported 120,795 tons; making a total consumption of rolled iron other than rails, in 1869, of 763,215 tons.

PRODUCT OF FORGES AND BLOOMARIES IN 1869,

was 69,500 tons, a slight decrease as compared with the average of the past five years.

Of steel of all kinds the product was 35,200 tons, of which nearly 12,000 tons was made by the Bessemer process.

From the reports of the British Board of Trade we find that the exports of iron of all kinds to the United States, from the various British ports (which represents nearly all the foreign iron entering into consumption here), during the year 1869, was as follows:

	Tons.
Pig-iron,	148,383
Bar, angle, bolt and rod,	62,807
Rails of all sorts,	336,500
Castings,	2,076
Hoop, sheet, and boiler-plate	37,233
Other wrought iron,	9,555
Total,	596,554
Steel,	18,601

By comparing these figures with those of the previous year, we find that of pig-iron the increase in 1869 was 54 per cent.; bar, angle, bolt and rod, 28 per cent.; railroad iron, 12 per cent.; hoops, sheet, and boiler plate, 80 per cent. ; other wrought iron, 71 per cent.; casting, 45 per cent. Total increase iron, 26 per cent. Of steel there was a decrease of about 3 per cent.

The history of the iron ore trade of the Marquette or Lake Superior region for the year 1869, is exceedingly satisfactory. During the year, 709,387 tons of ore were mined, the value of which, when loaded in the cars at the mines, is estimated at $3,166,190. The existence of iron ore in this region was made known in the year 1830, but the first opening was not made until late in the year 1846. From that time to the end of the year 1855, only about 25,000 tons were mined. Since the latter year the trade has grown with wonderful rapidity, the total quantity mined during the fourteen years that have since elapsed, reaching the vast aggregate of 2,274,490 tons. From this ore, over 2,000,000 tons of pig-iron have been smelted, a quantity equalling the whole production of the country during the year just closed. From the excellent History of the Iron Mines and Furnaces of the Lake Superior District, by A. P. Swineford, Esq., recently published, the following statement, showing the yearly production of ore in that region since 1856, is compiled :

Year.	Tons of 2,000 lbs.	Year.	Tons of 2,000 lbs.
1856	7,840	1864	263 338
1857	23,520	1865	219,807
1858	34,759	1866	332,609
1859	73,560	1876	522,005
1860	130,937	1868	568,750
1861	50,882	1869	700,387
1862	129,608		
1863	207,488	Total	3,274 490

FOREIGN IRON TRADE.

A few words touching the foreign iron trade for 1869 may not be inappropriate here.

In Scotland the demand for pig-iron at the commencement of the year was rather inactive, the price being 55s. cash. Trade was dull during the spring, and prices, after reaching 55s. 7d. cash, in March, to 52s. 9d., and finally near the close of May, receded to 50s. 7d. In June the trade improved, and prices went up again to 57s. 1½d. cash, again receding in July to 50s. 6d. From that time to the end of the year business steadily improved, the price advancing steadily until the close of the year, when it reached 57s. 3d. cash for mixed numbers f. o. b. The average price for the year was 53s. 3d. per ton, about 5s. below the average annual price for the last twenty-five years. The production during the year amounted to 1,150,000 tons, against 1,068,000 tons in 1868. At the close of the year there were 158 blast furnaces in Scotland, 120 of which were in blast. The stock of pig-iron in Scotland increased during the year 52,000 tons, there being 620,000 tons in store at the beginning of the present year. The foreign shipments of pig amounted to 388,639 tons, an increase of 64,620 tons. Of this increase nearly 50,000 tons was to this country.

In the great Cleveland district, which produces about one-fourth of the whole product of pig-iron in Great Britain, the iron manufacture was steadily progressive, and notwithstanding a largely increased make, the year closed with a lighter stock on hand than at the close of either of the two preceding years. The production of pig-iron in this region in 1869, was 1,459,500 tons, against 1,233,400 tons in 1868, an increase of 226,100 tons. The stock on hand was reduced 37,300 tons during the year. The price of Cleveland pig No. 3 was 45s. on the first day of January, 1869, and fluctuated but little during the spring.

In the summer the price fell to 43*s.* 6*d.* In September a heavy demand set in, principally from rail-makers, and the price rose to 50*s.* 6*d.* cash f. o. b.

The principal vitality in the Welsh market during the year was in the manufacture of rails, for which more remunerative prices were obtained than for other kinds of iron. A brisk demand for rails for the East India, Russian and United States markets continued throughout the year.

The exportation of iron of all kinds from Great Britain for 1869 has not yet appeared. The quantity of pig-iron made is estimated by the best authorities at 5,250,000 tons.

The exportation of iron of all kinds from Great Britain last year was conducted upon an immense scale.

	Tons.
Exportation of pig and puddled iron, ...	771,612
Against 552,999 tons the previous year.	
Of bar, angle, bolt and rod, ...	357,604
Against 302,624 tons in 1868.	
Of railroad iron the increase was marvellous, .	895,848
Against 583,488 in 1868; an increase of 312,360 tons, or 53.5 per cent.	

The whole of the increased activity noted was due to the heavy demands of Russia and the United States, the former taking 252,827 tons and the latter 300,446.

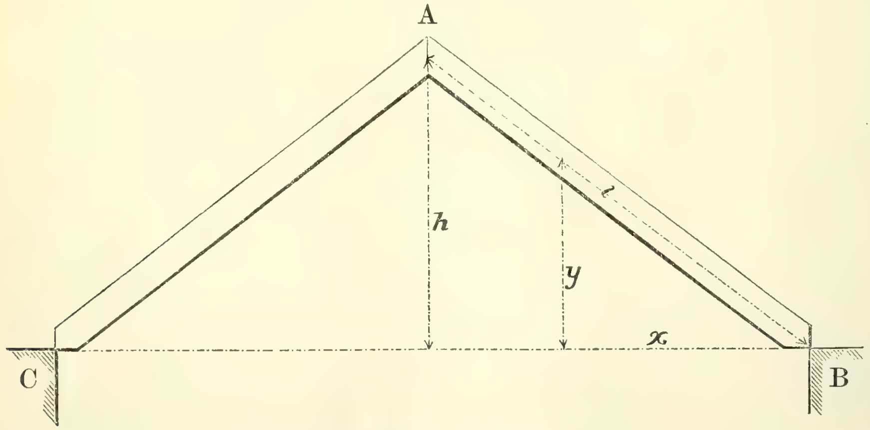
Castings were exported to the extent of 106,472 tons, compared with 85,504 tons in 1868; of hoops, sheets and boiler-plates 195,670 tons, against 150,231 tons the previous year; of miscellaneous wrought-iron 134,113 tons, as compared with 121,480 tons in 1868. The quantity of all kinds of iron exported was 2,577,493 tons, against 1,944,731 tons in 1868, an increase of 632,662 tons, or $32\frac{1}{2}$ per cent.

STRAINS IN RAFTERS.

By S. H. Shreve, C. E.

Rafters, and more especially trussed rafters, of great length are not in common use, and there may seem to be little need of the results of the investigations of the following paper in general practice. But the obscurity that exists in regard to the strains affecting rafters, and the consequent proof of the value of the methods which I have used in determining the strains in horizontal girders,* are sufficient reasons for the following investigations as an intermediate step between the consideration of horizontal and of arched trusses.

Fig. 1.



Mr. Stoney in his work on Strains, page 77, says of the strains affecting rafters, "an accurate investigation would be very complicated if not altogether impracticable."

This may be true in a certain sense only, as we cannot tell what lines strains take in a solid beam, whether inclined or horizontal, but it is not true in a flanged

*See pages 93 and 417 of the present volume of this magazine.

or trussed rafter any more than in a girder.

On page 76, Mr. Stoney also makes this singular assertion: "The longitudinal component of W compresses the rafter like a pillar, and accumulates gradually from the ridge, where it equals cipher, to the wall-plate, where it equals $\frac{h\,W}{2\,l}$." Our investigations lead to a very different result.

Let Figure 1 represent a pair of rafters, A B and A C.

Let w = the weight uniformly distributed over the pair.
s = the span of the roof.
l = the length of each rafter.
h = the height of the ridge above the wall.
x = the horizontal distance of any point in the rafter from the wall.
y = the vertical distance of the same point above the wall.
L = the longitudinal strain.

Each rafter is held in equilibrium by the horizontal thrust of the opposite rafter, the uniformly distributed weight of the roof, $\frac{w}{2}$ acting downward, the vertical reaction of the wall, which is $\frac{w}{2}$ and the horizontal reaction of the wall.

Taking moments around a point in the line of the top of the walls, distant x from one abutment, we have for the moment of the reaction of the wall, $\frac{w}{2} \times x$ in one direction; in the opposite direction we have the weight on $x = \frac{w}{s} \times x$ multiplied by the distance of its centre of gravity $\frac{x}{2}$, or $\frac{w\,x^2}{2\,s}$. Subtracting these, we have the moment of the longitudinal strain, which is L, multiplied by the distance at right angles to its direction from the point around which the moments are taken. This distance can be obtained from similar triangles by the proportion,

$$l : \frac{s}{2} : : y : \frac{s\,y}{2\,l}.$$

$\frac{s\,y}{2\,l}$ is the distance, and $\mathrm{L} \times \frac{s\,y}{2\,l}$ the moment of the longitudinal strain, and consequently,

$$\frac{\mathrm{L}\,s\,y}{2\,l} = \frac{w\,x}{2} - \frac{w\,x^2}{2\,s} \text{ and } \mathrm{L} = \frac{w\,l\,x}{s\,y} - \frac{w\,l\,x^2}{s^2 y} \qquad (1)$$

Again from similar triangles

$$x : y : : \frac{s}{2} : h \text{ or } \frac{x}{y} = \frac{s}{2\,h},$$

Whence, $\frac{w\,l\,x}{s\,y} = \frac{w\,l}{2\,h}$, and equation (1) assuming this form

$$\mathrm{L} = \frac{w\,l}{h}\left(1 - \frac{x}{s}\right), \qquad (2)$$

The values of x in this and the subsequent equations are limited between $x = 0$ and $x = \frac{s}{2}$,

Making $x = 0$, $\mathrm{L} = \frac{w\,l}{2\,h}$, the longitudinal strain at the wall; making $x = \frac{s}{2}$, $\mathrm{L} = \frac{w\,l}{4\,h}$, the longitudinal strain at the ridge.

In the above case, the moments were taken about a point where the horizontal reaction of the wall has no moment, merely to show that the longitudinal strain varies, and consequently that other strains, or strains having other directions, exist in a uniformly loaded rafter.

To ascertain these strains let A B in Fig. 2, represent a rafter which is a flanged beam, connected to the opposite rafter, and the wall by the upper flange only.

Let w, s, l, h, x, y and L have the same value as before, and let d = the depth of the rafter at right angles to its length.

h, x and y are measured to points in the upper flange.

All the strains between the two rafters pass through A and all the strains to the wall pass through B. From similar triangles, $\frac{s}{2} : l : : d : \frac{2\,d\,l}{s}$, the vertical depth of the rafter.

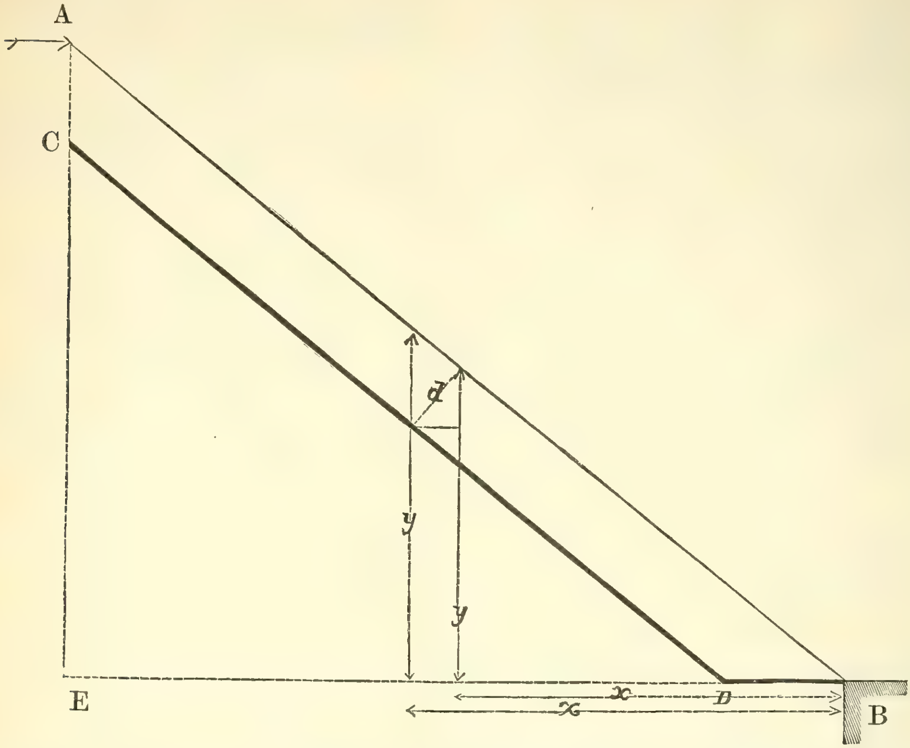
Taking moments around A, we have the moment of the reaction of the wall, $\frac{w\,s}{4}$, less the moment of the load on A B $\frac{w}{2} \cdot \frac{s}{4}$, which gives $\frac{w\,s}{8}$ for the moment of the horizontal reaction of the wall, and dividing by h we have $\frac{w\,s}{8\,h}$ for the amount of the horizontal reaction.

Taking a point in the lower flange, distant horizontally, x from the wall B, to obtain L, the longitudinal strain, in the upper flange at a place vertically over this point; we have,

$\frac{w\,x}{2}$ = the moment of the vertical reaction at B;

$\frac{w}{s} \times x \times \frac{x}{2} = \frac{w\,x^2}{2\,s}$ = the moment of the load on the part x;

FIG. 2.



$\frac{w\,s}{8\,h} \times \left(y - \frac{2\,d\,l}{s}\right) =$ the moment of the horizontal reaction at B; and

L $d =$ the moment of the longitudinal strain in the upper flange;

Whence

$$\mathrm{L}\,d = \frac{w\,x}{2} - \frac{w\,x^2}{2\,s} - \frac{w\,s}{8h}\left(y - \frac{2\,d\,l}{s}\right) \qquad (3)$$

or

$$\mathrm{L} = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,s} - \frac{w\,s\,y}{8\,h\,d} + \frac{w\,l}{4\,h},$$

But

$$y : x :: h : \frac{s}{2}, \text{ or } \frac{y}{h} = \frac{2\,x}{s}, \text{ and } \frac{w\,s\,y}{8\,h\,d} = \frac{w\,x}{4\,d}$$

And

$$\therefore \mathrm{L} = \frac{w\,x}{4\,d} = \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,p} \qquad (4)$$

Taking the moments around a point in the upper flange vertically above the point last taken, we have

$$\mathrm{L} = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,s} - \frac{w\,s\,y}{8\,h\,d},$$

and as

$$\frac{y}{h} = \frac{2\,x}{s},$$

$$\therefore \mathrm{L} = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} \qquad (5)$$

A strain differing from that in the upper flange in character, being tension while the other is compression, and in amount by the constant quantity, $\frac{w\,l}{4\,h}$.

In equation (4) L, the longitudinal strain in the upper flange, is greatest when $x = \frac{s}{4}$ or at the centre of the rafter.

When $x = 0$ or $\frac{s}{2}$, L or the longitudinal strain at B or A becomes $\frac{w\,l}{4\,h}$.

If there be any vertical strain passing through a or x, it would not appear in any of the previous equations because it would have no moment; but by taking moments outside of the vertical line passing through x, we can ascertain the amount of the vertical strain.

Let any point b be taken, but for simplicity let it be in the lower flange in a line perpendicular at a to A B. Let x' be its horizontal distance from the wall B, and $y' - \frac{2\,d\,l}{s}$ its vertical height above the wall.

Then, moment of vertical reaction of the wall $= \frac{w\,x'}{2}$.

Moment of horizontal reaction of the wall $= \frac{w\,s}{8\,h}\left(y' - \frac{2\,d\,i}{s}\right)$.

Moment of the load on a B $=$

$$\frac{w\,x}{s}\left(\frac{2\,x'-x}{2}\right),$$

Let L′ be the longitudinal strain at a, as found from these moments, then,

$$\text{L}'\,d = \frac{w\,x'}{2} - \frac{w\,x'\,x}{s} - \frac{w\,x^2}{2\,s} - \frac{w\,s\,y'}{8\,h} + \frac{w\,d\,l}{4\,h}$$

And since

$$\frac{y'}{h} = \frac{2\,x'}{s},$$

$$\text{L}' = \frac{w\,x'}{4\,d} - \frac{w\,x'\,x}{d\,s} + \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,h} \qquad (6)$$

Since L′ and L are the longitudinal strains which meet at a, and as one is greater than the other, their difference can be contained only in the vertical through a. It plainly follows that the moment of that difference is equal to the moment of the vertical force through a or x.

Let V $=$ the vertical force, then its moment is V $(x'-x)$.

And as $(\text{L}'-\text{L})\,d$ is the moment of the difference of the longitudinal strains, therefore

$$(\text{L}'-\text{L})\,d = \text{V}\,(x'-x) \text{ or V} = \text{L}'-\text{L}\left(\frac{d}{x'-x}\right);$$

From equations (4) and (6)

$$\text{L}'-\text{L} = \frac{w}{4\,d}\,(x'-x) - \frac{w\,x}{d\,s}\,(x'-x).$$

Multiplying by $\frac{d}{x'-x}$, (7)

$$\text{V} = \frac{w}{x} - \frac{w\,x}{s}$$

The vertical strain in the web of the rafter. When x in this equation equals $\frac{s}{4}$, V $= 0$; and V reaches its maximum when x equals $\frac{s}{2}$, or when $x = 0$, for in either case it is equal to $\frac{w}{4}$. The minus sign in this equation indicates, as it did in the examples of the horizontal girders, the weight going towards the abutment opposite to the one from which x is measured. In this case V has no value at the centre of the rafter and beyond towards the ridge, the weight passes towards the opposite rafter.

In the previous investigation of strains in horizontal girders, it was shown that the horizontal strains became zero at the ends of the girders, and we, consequently, had only the vertical force acting upon the abutments. Considering a rafter as a single girder, the longitudinal strain

$$\text{L} = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,h},$$

does not become zero at either end, for making $x = \frac{s}{2}$ or 0,

$$\text{L} = \frac{w\,l}{4\,h}.$$

Consequently in addition to the vertical strain of $\frac{w}{4}$ at the ends of the rafter, we have a longitudinal strain of $\frac{w\,l}{4\,h}$ thrusting upward at the ridge and downward at the wall.

We can resolve $\frac{w\,l}{4\,h}$ into vertical and horizontal components by the following proportions:

$l : h :: \frac{w\,t}{4\,h} : \frac{w}{4}$, the vertical component.

$l : \frac{s}{2} :: \frac{w\,l}{4\,h} : \frac{w\,s}{8\,h}$, the horizontal component.

The first being equal to the value of V at the ridge, and opposite to it, is neutralized by it, leaving only a horizontal force thrusting against the other rafter. At the wall where V again is equal to the vertical component of $\frac{w\,l}{4\,h}$, they act in the same direction, downwards, with a vertical force of $\frac{w}{2}$, while $\frac{w\,s}{8\,h}$ is the horizontal thrust against the wall.

$\frac{w\,l}{4\,h}$ being constant, its components are also constant, and to obtain the total vertical strain in a rafter, we have to add the vertical component $\frac{w}{4}$ to the vertical equation $\frac{w}{4} - \frac{w\,x}{s}$, and we obtain $\frac{w}{2} - \frac{w\,x}{s}$, an equation similar to that obtained for the horizontal girders, but which differs in being contained partly in the web and partly in one flange while the other was contained wholly in the web.

The upper flange is subject to compression, and the lower flange to tension, when the rafter is connected to the opposite rafter and to the wall by the upper flange. Joining the rafters to each other and to the wall by the lower flange, the longitudinal strain in the upper flange is by similar reasoning, $\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s}$, and in the lower flange,

$$\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} - \frac{w\,l}{4\,h}. \qquad (8)$$

In this case $\frac{w\,l}{4\,h}$ represents compression, while the remainder of the equation represents tension, or, if values be substituted, when their result has the minus sign there is compression, when the plus sign there is tension.

$\frac{w\,l}{4\,h}$ is constant and independent of the value of d, while the rest of the equation varies with the value of d; when, therefore,

$$\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} = \frac{w\,l}{4\,h},$$

we have a point where there is neither compression nor tension.

Let us give $\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s}$ its greatest value by making $x = \frac{s}{4}$ and we get $\frac{w\,s}{32\,d}$ at the centre of the rafter; making $\frac{w\,s}{32\,d} = \frac{w\,l}{4\,h}$, and we have neither compression nor tension at this point. But in this case d would become equal to $\frac{h\,s}{8\,l}$ or nearly $\frac{h}{4}$, an unnecessary depth. If the depth be less than $\frac{h\,s}{8\,l}$, then $\frac{w\,s}{32\,d}$ becomes greater than $\frac{w\,l}{4\,h}$, and the lower flange of the rafter is subject to tension in the centre and to the points on either side where $\frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,s} = \frac{w\,l}{4\,h}$, (where there is no strain) beyond there is compression, increasing to the end where it is $\frac{w\,l}{4\,h}$, to be resolved as before.

We have now obtained the longitudinal strains from the two flanges, where either one alone is united to the opposite rafter and the wall, and can obtain from the vertical force the strains on the members of the web, if the rafter be a truss regularly divided into panels; but it will be a simpler process to obtain the transverse strain, or strain at right angles to the rafter, and we shall then have two formulæ, corresponding to the horizontal and vertical formulæ, obtained in the cases of the horizontal girders; each formula representing a strain, no part of which is contained in the other.

The transverse strain can be obtained from the equation:

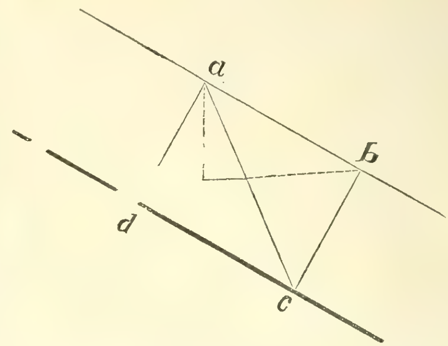
$$V = \frac{w}{4} - \frac{w\,x}{s},$$

by the following proportion,

$$l : \frac{s}{2} :: \frac{w}{4} - \frac{w\,x}{s} : \frac{w\,s}{8\,l} - \frac{w\,x}{2\,l} \qquad (9)$$

This strain can likewise be obtained in the following manner:

Fig. 3.



Let $a\,b\,c\,d$ be a section of a rafter or inclined truss, joined to the other rafter and the wall by its upper flange, and x and x' the horizontal distances of a and d from the wall; $\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,h}$ will be the longitudinal strain at a, and $\frac{w\,x'}{4\,d} - \frac{w\,x'^2}{2\,d\,s} + \frac{w\,l}{4\,h}$ will be the longitudinal strain at d. The difference has been united to a transverse strain or strain having a transverse component and has passed into the web or panel. This difference will bear the same proportion to $a\,d$ that the transverse strain united with it does to d, the depth of the rafter.

$\frac{s}{2} : l :: x - x' : \frac{2\,l\,(x - x')}{s}$ = the distance $a\,d$.

The difference of the two strains is

$$\frac{w}{4\,d}(x - x') - \frac{w}{d\,s}(x - x')\,\frac{(x + x')}{2}.$$

Then

$$\frac{2\,l\,(x - x')}{s} : d :: \frac{w}{4\,d}(x - x') - \frac{w}{d\,s}(x - x')\,\frac{(x + x')}{2} : \frac{w\,s}{8\,l} - \frac{w}{2\,l}\,\frac{(x + x')}{2}.$$

Making $\frac{x + x'}{2} = u$, when $a\,d$ is considered indefinitely small, or when there is a panel, the distance to its centre; we have

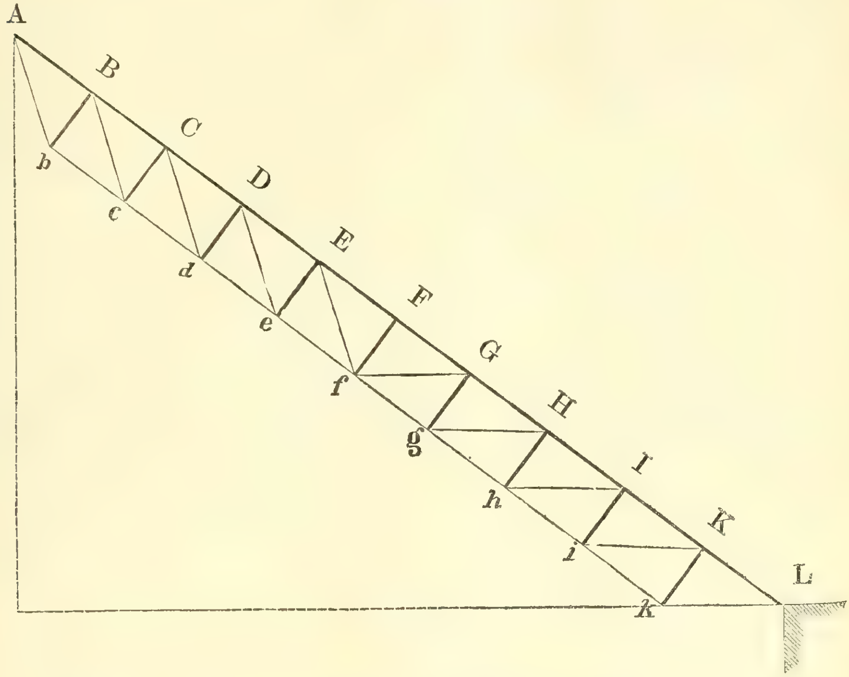
$$\frac{w\,s}{8\,l} - \frac{w\,u}{2\,l} \qquad (10)$$

for the transverse strain.

To make a practical application of the

formulæ obtained above, let figure (4) represent a rafter, trussed after the Howe system, and joined to the wall and to the opposite rafter by the upper chord.

FIG. 4.



Let $l = 125$ feet, the length of the rafter, from the ridge to the wall.

$s = 200$ feet, the span of the roof.

$h = 75$ feet, the height of the ridge above the wall.

$d = 6.25$ feet, the depth of the rafter.

$w = 100{,}000$ lbs. the weight uniformly distributed over the whole roof.

$x =$ the horizontal distance from the wall to the end of any panel in the chord connected to the wall and to the other rafter.

$u =$ the horizontal distance to the centre of any panel measured similarly to x

L = the longitudinal strain in either chord.

T = the transverse strain.

For the strains in the upper chord, we have equation (4).

$$L = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d} - \frac{w\,l}{4\,h}.$$

Substituting the values of the constants as given above; the equation becomes

$$L = 4000\,x - 40x^2 + 41666.$$

The first value of $x = 10$.

When L = 77667 lbs. Compression in K L and A B.

Next value of $x = 20$.

Whence L = 105667 lbs. Compression in I K and B C.

Next value of $x = 30$.

Whence L = 125667 lbs. Compression in H I and C D.

Next value of $x = 40$.

Whence L = 137667 lbs. Compression in G H and D E

Next value of $x = 50$.

Whence L = 141,667 lbs. Compression in F G and E F.

For the strains in the lower chords we have equation (5).

$$L = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s}$$

Substituting constants as before,

$$L = 4000\,x - 40\,x^2.$$

When $x = 10$, L = 36000 lbs. Tension in $i\,k$ and $b\,c$.

When $x = 20$, L = 64000 lbs. Tension in $h\,i$ and $c\,d$.

When $x = 30$, L = 84000 lbs. Tension in $g\,h$ and $d\,e$.

When $x = 40$, L = 96000 lbs. Tension in $f\,g$ or $e\,f$.

It will be seen that L has the same value for points on either side of the centre of the rafter, equally distant therefrom; for instance, L is the same whether $x = 30$ or 70.

When x has a certain value, say 20, L is the longitudinal strain at I and i. To the right of I and to the left of i, there is but one member subject to the longitudinal strain. It is therefore the strain in this member which is determined by the equation. The equation also gives the strain on the other sides of these two points, but it is there divided between two members.

Proceeding with the calculation, we have for the transverse strain equation (10),

$$T = \frac{w\,s}{8\,l} - \frac{w\,u}{2\,l}.$$

Substituting constants, T = 20000 – 400 u.

First value of $u = 5$, T = 18000 lbs. Compression in struts K k and B b.

There is the same strain in the ties k I and A b the longitudinal value of which is obtained by multiplying the transverse strain by the secant of the angle the tie makes with the strut 2.333.

Whence 18000 × 2.333 = 42000 lbs. Tension in k I and A b.

When $u = 15$, T = 14000 lbs. Compression in I i and C c.

14,000 × 2.333 = 32667 lbs. Tension in i K and c B.

When $u = 25$, T = 10000 lbs. Compression in H h and D d.

10000 ×2.333 = 23333 lbs. Tension in h I and d c.

When $u = 35$, T = 6000 lbs. Compression in G g and E e.

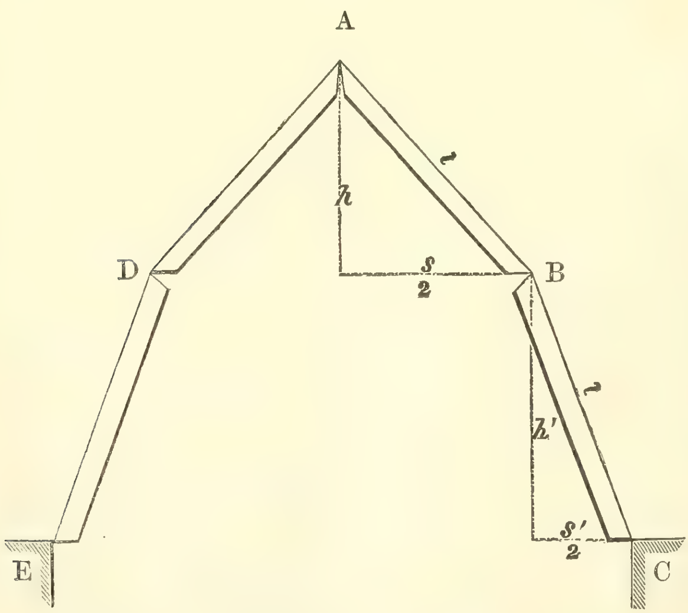
6000 × 2.333 =14000 lbs. Tension in g H and e D.

When $u = 45$, T = 2000 lbs. ×2 = 4000. Compression in F f.

2000 × 2.333 = 4667 lbs. Tension in f G and f E.

Now suppose the girder to be inverted so that b k becomes the upper chord while A L is the lower chord joined to the opposite rafter and the wall. Let the struts become ties and the ties struts, equation

Fig. 5.



(8) will then apply to the lower flange and will give the following results:

A B and K L will suffer 5667 lbs. compression.
B C and I K will suffer 22333 lbs. tension.
C D and H I will suffer 42333 lbs. "
D E and G H will suffer 54333 lbs. "
E F and F G will suffer 58333 lbs. "

The chord b k will suffer an amount of compression exactly equal to its tension when it was the lower chord.

In the same manner any other form of truss used for this purpose can be calculated, and the equations which were obtained for horizontal trusses can easily be adapted for similar rafters.

The resultant of the vertical force and

the horizontal force at the wall is not in a line with the rafter; for let the force $\frac{w}{2}$ be represented by h, then $\frac{w}{2} : \frac{w\,s}{8\,h} :: h : \frac{s}{4}$; or the resultant is the hypothenuse of a right-angled triangle, whose altitude is to h as its base is to $\frac{s}{4}$. This is true no matter what the weight may be, and if the roof is to be sustained by an inclined support, this gives the proper inclination.

If, however, this inclined support have weight of its own, and be in fact another rafter, and we are considering only the effects of the weights upon the rafters, then the inclination given above will be too great, because the weight of the lower rafter will increase the horizontal thrust and destroy the equilibrium of the roof.

To obtain the proper inclination, let Fig. 5 represent a roof of this kind.

h being the height of the ridge A above B, s the span A B and w the weight on D A B, $\frac{w\,s}{8\,h}$ is the horizontal thrust at A and B.

What shall be the inclination of B C, $\frac{w'}{2}$ being the weight it supports in addition to the weight from the rafter above, h' and $\frac{s'}{2}$ the vertical and horizontal distances between B and C? From two of these we can determine the third.

Taking moments around B we have the moment of the vertical reaction of the wall $=\left(\frac{w}{2}+\frac{w'}{2}\right)\frac{s'}{2}$. The moment of load on B C $=\frac{w'\,s'}{8}$, and the moment of the horizontal reaction of the wall $=\frac{w\,s\,h'}{8\,h}$. Whence,

$$\frac{w\,s'}{4\,h'}+\frac{w'\,s'}{4\,h'}-\frac{w'\,s'}{8\,h'}=\frac{w\,s}{8\,h}.$$

And

$$\left(w+\frac{w'}{2}\right)\frac{s'}{h'}=\frac{w\,s}{2\,h}.$$

We must give values to two of the quantities w', h', s', to obtain the third. Let for example $h'=h$, and we have

$$w+\frac{w'}{2} : \frac{w}{2} :: s : s'.$$

If $w=100000$, $w'=75000$ and $s=200$ ft. s' will be 72 ft., and $\frac{s'}{2}=36.4$ ft. In the same manner s' and w' being given, h' can be obtained.

WATER SUPPLY AND OTHER QUESTIONS IN INDIA.

From "The Builder."

The condition of the water supply in India has recently undergone a searching examination, and the results obtained are by no means satisfactory. The low-caste (or no-caste) natives of Bengal are not particular in the matter of water, and up to a very recent period Englishmen have thought far more of conquest than of sanitary regulations; so that the sources of water supply have been very little cared for. Tanks have accumulated vast masses of vegetation, and have abounded with fish and water-insect life. Wells, as a rule, have had no protection against surface pollution, and the results have been and are that both tanks and wells continue to be fearfully polluted, not only with vegetable and mineral matters in excess, but also with animal matter of the most revolting sort, namely, drowned bodies of natives. Any person conversant with Indian history knows that the poor Hindoo is a creature of impulse and despair; death has little of terror for a famine-stricken native, and suicide by drowning, even in tanks and wells known to be in use, is fearfully common, and human bodies are committed to the sacred waters of the Ganges in countless numbers; and yet this water is used by the residents on its banks and even in Calcutta. In the Bengal Presidency, during one year, upwards of 1,200 human bodies have been removed from tanks and wells, the water of which tanks and wells is in use as a supply for towns, villages, stations, barracks, hospitals, etc., and on cleansing some of these wells, many human bones have been removed, the flesh having wasted (dissolved) away. At many of the stations in this Presidency, Europeans on their first arrival suffer in various ways; as by fever, diarhœa, and cholera, by boils, and by entozoa and intestinal worms; regiment after regiment, as the men have arrived, going through this disgusting routine of

drinking tainted water and paying the penalty in human sufferings. Recent chemical analyses show that a vast proportion of these diseases is preventable. The Presidency of Bengal is a region of heat, moisture, rivers, swamps, jungle, and cholera; and it is in this vast district that this dreaded disease (cholera) obtains its birth, and, in its terrible maturity and strength, passes forth over the inhabited parts of the earth to teach men that they must pay the penalty of a sudden and loathsome death if the simple laws of nature are neglected, or are blindly and selfishly broken. It has long been known that polluted water is, during epidemic periods, a deadly poison; and if water pollution and cholera are cause and effect, the tainted wells and tanks of Bengal only perform their natural work. The preparations and the results are in accord. Tanks and wells are neglected; and, consequently, are po luted to the uttermost; the population, native and European, blindly and ignorantly drink the waters and suffer accordingly. From the grand ranges of the vast snow-capped Himalayan mountains to the sea, over the regions watered by the sacred Ganges and its numerous tributaries, this neglect prevails. The monsoons bring deluging rains and relief, for as the waters rise cholera disappears, being drowned out of the submerged swamps and vast alluvial plains, but only to reappear on the subsidence of the great flood waters, as the tropical heat evaporates the sodden soil and rotting vegetation. The mortality in such a district, so neglected, has been very great. The questions now are, "Need such mortality continue?" "Must European life be expended at the rate common to periods which have passed?" On the nature of the answers to these questions depends the supremacy of British power in India for a shorter or a longer period. Sanitary science teaches this lesson. Abandon stations situated in swamps and jungles; cleanse and protect all sources of water supply, and establish a sanitary police both for the native and for the British populations; remove every known cause of disease which is removable; wash and be clean; but see that the water is free from pollution. The continued government of India by Europeans cannot be. Great Britain may plant her pure religion, her civil law, and her sanitary order; but she will not govern in perpetuity. She may devise canals, tanks, and wells furnishing pure water, and construct net-works of highways and roads, common and iron; foster native manufactures, and encourage commerce; but in due time her work will have been accomplished and her labors must cease. In the future history of the world the facts and incidents connected with British power in India most dwelt upon will not be of armies, generals, governors, and conquests; of battles, suppressions of mutiny, or of human slaughter in any form. The memory of these may remain, breeding feelings of revenge, or of shame, or of sorrow, in proportion as the hearts of those who read are hardened, or have been civilized by Christian teaching. The true and enduring fame of Great Britain will be connected with the permanent establishment of works and regulations of the most simple character, namely, those works which have tended to promote social comfort, and those regulations which have best insured human happiness, and are a means of securing health to the greatest numbers.

J. J. Smith and T. Eastwood have patented an improved working valve of steam-engines. The eccentric rods are attached to an oscillating bar having a slot in the centre thereof, through which a pin attached to the valve spindle is passed. The oscillating bar works in and imparts its motion to a "compensating bar" contained within the fork of the valve spindle, the pin attaching the parts together also passing through the box. Wedges are inserted between the ends of the oscillating bar and the compensating box to take up or compensate for any wear that may occur by reason of the friction or lamination of the surfaces.

A new furnace has been erected at the Franklin Iron works in Oneida county, N. Y., and is now in blast. It has a diameter of 14 ft. at the bosh, and a height of 54 ft. It is yielding 25 tons of No. 1 iron per day upon a consumption of 1 ton 5 cwt. of coal.

The capital stock of the Altman Miller Co., at Akron, O., has been increased to $300,000.

HEATING BUILDINGS BY HOT WATER.

From "The Mechanics' Magazine."

The proverbially fickle climate of the British islands, and the frequent recurrence of a damp and cold atmosphere, make the application of artificial heat to our dwellings and public buildings a positive necessity. Contrivances for producing an equable temperature within doors are consequently numerous, and in many instances they are of an ingenious character. Perhaps the best mode of accomplishing the desired end, as well as the simplest, is that of causing the circulation of hot water through iron pipes conveniently disposed for the purpose. Up to a very recent period, however, a considerable amount of hostile prejudice existed in regard to the use of hot water apparatus, and even now the plan of heating buildings by such agencies is not fully appreciated. Imagining that antipathy to the system arises in many cases from a lack of acquaintance with its peculiar merits, we shall endeavor to explain the principles which govern the action of hot water apparatus generally, and furnish some information as to their best form and proportions. In order to do this effectually, we must first glance at one or two of the natural laws which affect the circulation of fluids and gases. That all falling bodies gravitate with the same velocity, and therefore descend through a certain definite space in a given time, is an effect of which gravity is the cause. It is from this cause that we obtain the unerring action of the pendulum. To the same source may be distinctly traced the phenomena attending the circulation of hot water through pipes, and this circulation, once created, forces all the water in the apparatus to pass successively through the boiler by which it is primarily heated. It is upon the continuous and uniform movement of the water along the pipes that the efficiency of the hot water apparatus immediately depends. Let us, then, inquire as to the power which insures this vitality, for without a clear perception of its nature there will ever be uncertainty as to the working of any apparatus of the kind in question. The force which produces circulation arises from the fact that the water in the descending pipe is heavier than that which is in the boiler, or, to put it differently, when heat is applied to the boiler a dilatation of the water within it ensues. The heated particles ascend through the colder ones, whilst the latter descend by reason of their greater specific gravity and in turn become also heated. Expansion follows, and this species of action and reaction proceeds until all the particles are equally heated. It follows that the colder the water is in the descending pipe, relatively with that in the boiler, the more rapid will be its motion through the circulating pipes, and hence the diffusion of heat through their pores and into the atmosphere surrounding them.

Thus much of the general principles which control the action of hot water apparatus as applied to the heating of buildings, and now as to their particular dimensions and details. These will naturally have to be varied with the character and size of the buildings to be heated. For churches and large structures of a similar kind, and which have an ordinary number of doors and windows, it will be necessary in devising hot water apparatus to ascertain, first, the cubic contents of the auditorium. Having obtained this knowledge, let the number gained be divided by 200. The quotient will yield the length in feet of 4 in. pipe required to maintain something like a steady temperature of 55 deg. For smaller apartments, as, for example, dwelling-houses, etc., the cubic measurement divided by 150 will furnish the proper length of 4 in. pipe. These simple rules, which are the result of extensive practice and careful observation, may be safely relied upon, unless under very exceptional circumstances, and which, of course, would have to be duly considered by the constructor of an apparatus intended to meet them.

In reference to greenhouses, conservatories, and buildings of a like character, where the temperature should reach a mean of 60 deg., the sum of the cubic contents divided by 30 will give the length in feet of 4 in. pipe required to produce the desired effect. Forcing houses, again, must have special calculations made for properly heating them. Nothing short of a uniform temperature of 70 deg. to 75

deg. will suffice for such places. In order to insure this the measurement, as before suggested, must be divided by 20, the quotient being the length of circulating pipe required. For gaining yet higher temperatures, lower divisors will have to be employed, and if smaller pipes be determined upon, the length must be proportionately increased. These are points of detail, however, which may be safely left to the skilled manufacturer who may be intrusted with the making of hot water apparatus for special purposes. Our own data may be taken as the base of calculations for economically and effectually heating buildings by means of hot water.

We are aware that some horticulturists have adopted the plan of heating their forcing houses to a much higher temperature than that indicated above, and of allowing a greater amount of ventilation than is usual. By aid of such arrangements, it is said, a finer fruitage is obtained, but there is no doubt that this course involves increased expense in the first cost of the heating apparatus, together with a large augmentation in the subsequent daily consumption of fuel for working it.

An important consideration to the horticulturist and floriculturist is the waste of heat through glass roofs and walls. It has been found, from a course of carefully made experiments, that one square foot of glass will cool 1.279 cubic feet of air as many degrees per minute as the internal temperature of the house exceeds the external temperature. Thus, if the difference between the internal and the external temperature be 30 deg., 1.279 cubic ft. of air will be cooled 30 deg. by each sq. foot of glass in the building which is exposed also to the outer atmosphere. It will be admitted that this fact should be allowed its due weight in contriving hot water apparatuses for houses wholly or partly constructed of glass. Of course, in estimating the area of glass, due deductions must be made for the sash frames and wood-work by which the panes are surrounded. If the frames and sashes be made of metal, the radiation and consequent loss of heat through them will be equal in extent to that which results from the glass itself.

The quantity of air to be heated per minute, so far as conservatories and forcing houses are concerned, should not be less than $1\frac{1}{4}$ cubic ft. for each sq. foot of glass which the building contains. When the quantity of heated air required has been thus ascertained, the length of pipe may be determined by the following formula, viz. :—Multiply 125 by the difference between the temperature at which the house is proposed to be kept (when at its maximum) and the temperature of the external air, and divide the product by the difference between the temperature of the pipes (200 deg.) and the proposed temperature of the room. Then the quotient multiplied by the number of cubic ft. of air to be heated per min., and its product divided by 222, will give the number of ft. of 4 in. pipe to yield the desired effect.

Although our remarks on this subject have extended beyond the limits originally intended, a word or two must be said as to the quality of the water to be used for heating purposes. Sometimes foul water is employed, under the impression that anything will do for the hot water apparatus. This is a grievous error, for the result will be the deposit of a coating of mud or other material throughout the pipes, thus impairing their radiating action and efficiency. The boiler, too, will suffer if it be not eventually destroyed by such a neglect of ordinary precautions. When saline matter occurs in a boiler, obviously damage to it and waste of fuel must be the consequence. The sediment can only be removed with difficulty. A weak solution of muriatic acid will assist in effecting its dispersion. Rain water is better adapted for use in heating apparatuses than water of any other kind, and when obtainable, therefore, it should always be employed. When an apparatus is disused for a time and left with water standing in the pipes, there is danger of the latter freezing. Possibly the pipes may burst under such circumstances. It is a wise precaution, therefore, to leave the pipes either entirely or partially empty, when the apparatus is not likely to be put into action for any length of time. With ordinary care the hot water apparatus may be made to last—if originally well constructed—for very many years. It is really an economical application of science to the practical wants of daily life, and we predicate for it a widely extended field of usefulness when its advantages are more

completely understood. In London there are several very successful constructors of apparatus for heating buildings, but it would be invidious to particularize them. Our object is to attract the attention of those interested to a branch of economic science which has hitherto obtained far too little public notice.

THE TAJ-MAHAL AT AGRA.*

From "The Builder."

During a stay of three or four years in the East, one meets with so much worth describing that on being asked by friends in the cold civilized West what one has seen, it is sometimes a difficult matter to know what people, countries, customs, or buildings to tell about first; but in the spring of last year it was my good fortune to find myself in the cities of the old Moguls—Agra and Delhi—and of all places I have been to, either in the West or East, I unhesitatingly affirm that Agra and the Taj-Mahal stand pre-eminent in the impression made on my mind.

Venice, with its Grand Canal and St. Mark's, numerous palaces and art works; Constantinople and the Bosphorus, with the Sta. Sophia and Sulieman Mosques; Cairo, with its beautiful Hassan and interesting Tooloun Mosques, picturesque streets, and Coptic churches and ruins, and the huge ugly pyramids; and Bejapore, with its big dome and elaborate Ebrahim Roza, all fall into the shade contrasted with Agra and its Taj-Mahal. Its romantic situation, dazzling brilliancy, excessive elaboration, and the particularly refined, though lavish display of wealth in its ornamentation, make it beyond all others a place in which a cold-blooded Caucasian can perhaps realize somewhat of the poetical and luxurious feeling of the voluptuous Easterns.

The Taj-Mahal was built about the year 1040 of the Hijree, or 1662 A. D., about the time of the Restoration, and during the latter years of the reign of Kurreem Shah, the fifth of the Mo ul Emperors, grandson of the great Akbar, and son of Jehangir. He is more commonly known by his assumed title of Shah Jehan, signifying the King of Worlds. It was erected as a tomb for his wife, the Begum, Ungeman Bunnoo, whose title was Moomtaz Mahal, daughter of Azif Khan, and granddaughter of the Nawab Ettmadowla. She was also called Taj-Mahal, and Noor-Mahal, which means the Light of the Hareem or Palace. She is immortalized in our own language in Moore's beautiful poem of "Lalla Rookh." She had four sons and four daughters; the youngest daughter's name was Dhahur Arra, at whose birth Taj-Mahal died. Shah Jehan was exceedingly fond of her, and on her death-bed he promised two things, first, "That he would never marry again;" and, second, that he would build for her so magnificent a tomb that it should surpass all others the world ever saw.

The tomb is erected on the left bank of the river Jumna, and Shah Jehan's intention was to have erected another for himself of equal splendor on the opposite bank, connecting the two by a bridge with silver railings, so that after death their souls might be enabled to hold spiritual communion with each other. He went so far as to put in the foundations of the second, when his demise put a stop to further proceedings, and he lies, in consequence, by the side of his wife in her tomb, her sarcophagus occupying the centre position.

The Taj buildings altogether form a parallelogram. They consist of the Taj proper, placed on a raised dais of white marble, some 20 ft. high and 300 ft. square, situated in the centre of the end of the parallelogram immediately overlooking the Jumna, and flanked on each side by red sandstone buildings, separated from the raised dais by courts about 400 ft. wide, paved with marbles laid in geometrical patterns. One of these buildings is a mosque, the other is of no use but for its architectural effect in contrasting and grouping with the Taj, and is called by the natives the Jawab, which means "answer," and I think very well describes its meaning and use. This mosque and Jawab are of red sandstone and white and black marbles, and inlaid with precious

* From a paper by Mr. W. Emerson, read at a recent meeting of the Royal Institute of British Architects.

stones, something similar in design to the entrance gateway I shall presently describe. On the floor of this Jawab are outlines of the dome and finials, and some other portions of the Taj, cut in the pavement for the men to work from.

As one drives into the outer court-yard, and pulls up opposite the grand entrance, the beauty and magnificence of the place immediately strike one. The gateway is two stories in height; in elevation, it has a large and deep central recess, a semi-octagon on plan, domed over and flanked on either side by two smaller recesses, those on the upper floors forming galleries, and with large octagonal turrets at the extreme angle surmounted by domes supported on columns and arches. The grand centre arch is also surmounted by a row of 11 little domes on columns and arches, and flanked by slender minarets; the effect of these is particularly beautiful. It is built of red sandstone, inlaid with white and black marbles. The spandrels over the arches are of white marble, inlaid with semi-precious stones in the same manner as the tomb itself, only the work is of much larger design and rougher execution. The gateway forms a square room with large entrance arches on two sides, the outside one being hung with gates, and on the two other sides smaller doorways leading to rooms on either side, and to a staircase which leads to the galleries over these smaller rooms. A seat runs round the room, and on one side is a platform for the use of servants, soldiers, and gatekeepers. The lower part of the wall has a dado, formed of panels of white marble, enclosed by a border of inlaid white and black marble in a zig-zag pattern. Over and at the sides of the smaller side-doors are the peculiar little arched recesses used for placing lamps in at the time of a festival. The friezes are inlaid with sentences from the Koran. This gateway is domed over, faced internally with white choonam (or plaster) and ornamented with black lines, radiating from the centre, which accentuate the raised ridges dividing the little hollowed spaces, forming the surface ornamentation of the interior of the dome. The gates themselves are of teak, covered with a plating of bronze, with a raised pattern on it, in shape a mixture of a quatrefoil and rectilinear figure. Through this gateway, at the end of a long avenue of cypress trees, the centre of the avenue being occupied by marble fountains, basins, and flower beds, the Taj-Mahal, dazzling the eyes with its whiteness, is seen. On walking up the avenue and through the gardens, I could not help feeling it to be a more beautiful place than I ever dreamed of. There is almost every description and variety of flower, and on a hot day the cool sound of the water trickling along the little aqueducts which carry it to all parts of the grounds, the shady walks, and parts of the paths arched over by creepers, covered with flowers of most gorgeous colors, and the mango, guava, orange, lime and loquat trees, combine to make it a most pleasant resort. Leaving the gardens, and ascending a flight of marble steps and crossing the platform of white marble which in the bright sun dazzles the eyes so as to make them water copiously, and with "Salaam Sahib, Salaam Sahib," from the old Mussulman priests at the entrance, one finds one's self in the inside of the Taj itself.

The contrast between the bright light outside and the solemn gloom inside is so great, that for some minutes you can see nothing. Gradually this wears off, and one sees tolerably well, though to do drawings inside I was often obliged to get natives to hold candles for me. The plan is an irregular octagon outside, while the centre room is a regular octagon, recessed on each side, and about 60 ft. in diameter, and 80 ft. in height, with circular rooms in each angle of the building, connected by passages running all round the centre apartment. Under this centre apartment is a crypt or small chamber, in which are the sarcophagi that really contain the bodies of Shah Jehan and Taj-Mahal. The centre portion of the inner apartment is screened off and contains the show tombs, on which the natives strew flowers, etc.

The way in which light is obtained through the outer chambers and double walls, there being in no case a direct light into the principal room, and what does enter being broken by the trellis work that fills the openings, causes a wonderfully cool and solemn effect on first entering. At each corner of the raised dais on which the tomb is placed are minarets.

The building is two stories high, the centre room running up the whole height of both stories. Access can also be had to the roof, which is flat, and has four

smaller domes supported on piers and arches, one over each corner circular apartment. The centre chamber is surmounted by a double dome—the one forming the ceiling being about 80 ft. from the ground, and the upper one being about 260 ft. high, and is the principal feature in a distant view of the Taj group. The external elevation of the four principal sides is the same, also the four angle fronts are the same design. The arrangement of these façades is very simple. The principal ones are divided into three parts. In the centre part is a large, well-proportioned, recessed entrance arch, the height of the two stories, and surmounted by a parapet and two minarets, which being carried down to the ground as slender octagonal shafts, form the division between the main central recessed portion and the smaller parts which flank it. These side parts of principal elevations have two arched recesses much smaller than the central one, placed one over the other, and forming the two stories in height, and are exactly similar to angle elevations, being again divided from them by minarets as before described. All these recesses are square on plan, and have at back arched and square-headed openings, which are fitted with the marble trellis-work for admission of light The domes, which are over the four angles, are supported by piers and arches, the arches being foiled after the Saracenic fashion. The domes spring from a cornice formed of plain projecting slabs of marble, supported by cantilevers.

In the centre rises the huge bulbous dome, which forms the grand central feature of the Taj. It springs from a plain straight circular shaft, which rises to about the height of the tops of smaller domes. A plain twisted bead mould marks the springing. The peculiarity of this and other Musselman domes in India is the bulbous shape obtained by making them swell out considerably beyond the springing line. This form obtains at Bejapore to a great extent. This dome is topped by a huge gilded finial with a golden crescent. The walls are mainly built of red sandstone, but completely encased with white marble. This is not done in the veneering fashion of Italy and Egypt. Each slab of marble is 4, 6, or even 8 in. in thickness. In the construction of the dome, and other places where it would not interfere with the after ornamentation, it is built up with the walls, laying first a course as slabs of flat masonry, and then a course on edge, thereby obtaining good bond, and an external effect of alternate broad and narrow courses of about 18 in. and 4 in. in depth, so that riveting was never needed.

This method obtained in many places in India, where their building stone was wedged out of the quarries in large flat slabs. About Agra and Delhi all the buildings, whether of red sandstone or marble, were done in this manner; the interior of the walls was filled in with rubble.

Were it not for the elaborate inlaid work, which partakes more of the nature of jewelry than architecture, this building would be the simplest in the world, but very effective, nevertheless — first, of course, owing to its grouping and proportion. Then its large broad plain surfaces are undisturbed in their repose by any projecting mouldings, while the cool delicate shadows in the large arched recesses cause quite a sufficient balance between the light and shade. The spandrels to arches and the illuminated surfaces are, as a rule, set back about an inch. The plinth projects about an inch, and a slender string, projecting very slightly, accentuates the parapet. I think these, with the bead round the springing of the large dome, and cornices of smaller domes, and the leaves at the apex, are the only particular lines formed by shade throughout the whole external face of the building.

One thing that lends a most peculiar charm to this tomb, is the wonderful delicacy of the shadows caused by the strong reflected lights. The pavement of the raised dais being all white marble, it reflects in so powerful a manner that it reduces the depth of all the shadows by quite a half, if not by more.

One general feature in the ornamentation of the Taj is the inlaid black marble. Every angle, arch, panel, recess, in fact the outline of each component part, is marked by lines of black marble, either 1, 2, 3, or more inches in breadth, according to the size or importance of the detail requiring accentuation. This, of course, accounts in a great measure for the absence of any mouldings, and I am inclined to think this method of ornamenta-

tion, or, more properly, accentuation, disturbs the grand repose of a building much less than any other method employing shade as the means.

Probably the greatest ornaments to, and most perfect pieces of work in connection with the Taj, are the four minarets at the corners. They are about 200 ft. high, and about 20 ft. in diameter at the base ; but the proportion of these is so subtle, that the slightest alteration, by either increasing or decreasing the diameter, or taper, or height, one feels would immediately spoil their effect. They are most elegant, but have not the starved appearance of the minarets of Egypt, Constantinople, and Delhi. They are three stages in height. At each stage a light balcony, supported on cantilevers, running round the tower, and they are surmounted by domes on gilt columns, and foiled Saracenic arches and gilt finials. Winding stairs take one to the summit, to which stairs access is obtained by means of square-headed doors.

I mentioned before that each course of white marble is divided by a narrow course of black, which in the distance gives an appearance of very thick joints, and makes the circular shaft tell out wonderfully in perspective.

The mausoleum itself is ornamented to a height of about 6 ft., with panels, forming a sort of dado, edged with a border of inlaid work in semi-precious stones of various colors, and each panel being carved in relief with flowers growing out of pots—the lotus, rose, etc. The carving of these is very beautiful, finished as finely and as polished in every little detail as any Italian work, and with all the freshness of design and arrangement of Mediæval art. Around the arches the Koran is illuminated in black marble. In this manner, it is said, the whole Koran is inscribed on the Taj walls. The spandrels of the arches are inlaid with a flowing ornament of graceful design, in semi-precious stones. The angle shafts, forming minarets, have zig-zag lines inlaid in black marble. Under the parapets is a running pattern, also inlaid ; and in the parapet itself is an inlaid pattern of bold design, in colored stones.

The interior is, in the same manner as the outside, ornamented with a carved and inlaid dado ; but the carving is richer, and the inlaying more elaborate.

The dome, which is very dark, is covered all over with the pattern peculiar to Indian Mussulman architecture, which is formed by lines radiating from the centre, crosswise, and the spaces thus formed (which, of course, increases in size as the lines approach the springing of the dome) are hollowed ; by this means the radiating lines are in reality formed by the ridges dividing the hollowed spaces. This is often elaborated to such an extent that it is impossible for the eye to follow the pattern.

I now come to the part of the building which is the most wonderful and elaborate part of it all, namely, the tombs and the screen enclosing them, all of purest white marble. The screen encloses an octagonal space. Each side of the octagon is divided into three bays ; the centre bay of the side facing the entrance door is an archway into the enclosure ; all the other bays are like to each other, and of similar design to the part at the side of the arch. At each angle and between each bay, are posts supporting perforated screens, each of a single slab of marble. It is very Italian in feeling. An eighth portion of it contains the whole design ; this is reversed and turned upside down to form the whole screen. It is, I should think, the most elaborate piece of marble perforation in the world, and is polished all over ; both sides are finished alike. The screens are surmounted with a sort of balustrade of carved and inlaid work.

But the most extraordinary part is the inlaid work on the pure white marble posts, rails, arch, and tombs. The tombs, both in the enclosure and in the crypt below, are simple parallelograms about 2 ft. high, with a small sarcophagus in the centre of each, on a plinth formed of two cymatium members, and fillets, and the top slab having an ogee mould.

The inlaid work is most elaborate, representing all sorts of flowers, worked in semi-precious stones—the stones carefully picked for each particular leaf, so that all shading and drawing of leaves is obtained by the graduated natural color or marks in the stones themselves. At the side of the central tomb is the following inscription, in Persian :—" The splendid tomb of Unjeman Bunnoo Begum, whose title was Moomtaz Mahal, was made in 1040 of the Hijree," and on the side of the other is :—" The magnificent

tomb of the king, inhabitant of the two heavens, Ridwan and Khool, the most sublime sitter on the throne of Illeeyn (*i. e.*, starry heavens), dweller in Firdoos (*i. e.*, Paradise), Shah Jehan Badsha Gazee, peace to his remains, heaven is for him. His death took place the 26th day of Rujub, in the year 1076 of the Hijree. From this transitory world eternity has carried him off to the next."

In some of the roses, which are no bigger than a franc, there are 30 pieces of stone, and the jointing is generally scarcely visible. It is, in fact, jewelry. Indeed, in the centres of the flowers on the head of the tomb there were originally large emeralds and rubies, but these were stolen during the Maharatta wars. The ornament is in some places of a flowing pattern ; in others, like little trees in full bloom, with magnificent flowers. The colors of the stones are arranged with such taste, and the effect is so quiet, that it is only after looking about for some time that one finds out what it is that gives the interior such a rich appearance. Not a single flower forces itself unduly on the eyes, and I have seen Europeans walk for the first time into the Taj, and go all round and out again, without ever noticing anything particular in the ornamentation of this screen and tombs. What they do notice at once is the soft echoing of every little sound. A musical note echoes and re-echoes through the dome, gradually and softly dying away. The natives believe these voices to belong to the unseen heavenly bodies, who watch over Noor Jehan and her husband. The most delicious harmony I ever heard was some singing by ladies in this tomb. The interior has the most solemn effect on one's mind—there is an amount of pathos in it that causes feelings in a sensitive person much the same as reading an affecting melancholy love-story, so much so that it almost forces tears to one's eyes.

The whole cost is said to have been about three millions of our money. It took 17 years in building, and the labor was all forced—the workmen being kept on a daily allowance of rice. Orientals say it was built by one Isa Mahmoud, an architect sent from Turkey to Shah Jehan for the purpose. Others say a man named Austin de Bordeaux, a French architect, designed it. As to whether purely Oriental, or in some measure European, I should be afraid to give a decided opinion. I think there is much of Italian feeling in the screen, and also in the four minarets and some details of the cantilevers. But then at Bejapore, and other places in India, I thought the same with regard to many details, and no one seems to doubt that the art of Bejapore is purely Oriental. Still it is possible that Italian artists may have had something to do with it in detail ; and I believe in some old manuscript accounts, mention is made of payments to a foreign artist. But this may have alluded to Isa Mahmoud, or Persian artists. It was built at a time when Italians were to be found all over the world, fleeing from ducal tyranny, and some may have found their way into the centre of India ; and they could have ingratiated themselves in no more favorable manner with the luxurious Mogul Emperors than by assistance in the art of magnificent building.

RIVAL GUN-CARRIAGES.

From "The London Times."

When an invention appears before the world ready for adoption everybody wonders at its simplicity, and asks, with surprise, "How is it we never thought of it before?" Such was the case with the Moncrieff carriage, which had cost the inventor 10 years to work out. The idea of using the force of recoil to raise another gun, or a weight that might in its turn lift the piece which had raised it, was by no means new. It had been tried many a time, and had always failed. But the manner of doing it and the success were new. The difficulty of the problem has been brought home to the minds of all by the trial of another apparatus at Woolwich, a sort of rival to that of Moncrieff. It was built according to an idea of Capt. Grant, inventor of the well-known field kitchen. The Royal Carriage Department had worked out his proposal. Yet, with all the talent of the inventor,

with all the assistance of experienced officials who have had Moncrieff's invention continually before them, the arrangements were manifestly imperfect, and the result was a failure.

The gun used for the experiment was a 7-in. breech-loading Armstrong. Together with its carriage it weighed about 5 tons. The carriage was placed on an inclined slide, consisting of two large side beams connected by cross pieces. The raised end of the platform was supported on heavy beams of wood, and underneath all was a platform very similar to the slide above, and mounted on trucks which ran upon curved iron racers or rails. The appearance of the whole was that of two right-angled triangles of heavy wood with their longest sides uppermost, the triangles being connected by cross beams of wood. Heavy chains were attached to the carriage, led over strong rollers at the highest angles of the apparatus, and then fastened to a counterpoise, weighing 6 tons. The counterpoise slid down the lower surface of the incline, being held from falling by grooves in which it moved. Some of the friction was saved by small rollers on the upper part of the counterpoise, and because it is well known that to impart sudden motion to a heavy body causes a great shock, unless that body be freely suspended. Strong india-rubber springs or buffers were placed where the chain was attached to the carriage, and also where it was fastened to the counterpoise. The apparatus was simple enough, but a glance was enough to show any one at all accustomed to such matters that the strain must be tremendous.

To explain simply the difference in general principle between the Moncrieff method of storing up recoil and this one, we will give a familiar illustration, putting aside all the practical advantage obtained by the peculiar curve of the Moncrieff elevators or rockers, and all the disadvantage of the friction caused by gun-carriage and counterpoise in the new apparatus having to work in grooves.

Suppose that a great weight has to be lifted from the ground very suddenly, and with as little shock as possible, because it is advisable that your apparatus shall last a long time—two methods are offered to you.

One is a rope simply led over a pulley at the end of an inclined beam or frame, one end fastened to the weight, the other in your hand. The pull is, from the nature of the case, to be a sudden one, not slow and gradual. Will there not be a great shock to your arms, and a dangerously sudden and severe strain upon the rope, communicated also to the pulley, and through it to the inclined frame, tending to force it backwards in the direction in which your sudden pull operates? Will there not be a tendency in the whole frame-work to tear away the supports by which it is fastened to the ground? This is the new apparatus.

The second plan offered you is to have the weight fastened to one of the ends of a large rocker shaped like a half-moon, so that the weighted end is down and the other nearly perpendicular above it. In this case your pull is to be applied to the upper end, and you have only to make the half-moon roll on its curved surface. Surely every one must feel at once, even without more knowledge of mechanism than nature has taught him, that in this case the weight will be moved with less strain upon the arms and with no danger of breaking or shifting anything from its place. This is the Moncrieff principle in its broadest features.

But to go a step further, and suppose that in the first case you have not only to lift the weight, but to make it slide in a groove so that it must rub against the sides. All the strains are evidently increased. On the other hand, in the second case, suppose that your rocker is not in the form of a half-moon, but has the end next the weight rounded off in a sharp curve. It must be felt that the first strain is still further decreased. What the ordinary daily acquaintance with nature teaches, so that experience soon makes men feel what is generally right or wrong, mechanicians can calculate with accuracy; and although in the case of the apparatus tried, the weight had not to be lifted directly, but drawn up an inclined plane, so much friction was introduced that it was evident the shock and strain must be terrible.

The first fact remarked by the spectators was that the counterpoise did not bring the gun up to the firing position by its own weight, but that the gunners had to use tackle and much force for the purpose. The second was that the height which the gun rose and fell was small in

proportion to the distance it had to move backwards and forwards, so that a shot coming over the parapet and falling at an angle not less than the incline of the platform would have the gun exposed to it at whatever point in its ascent or descent the piece might be. Then it could not but be observed that there would be no means of loading if the 7-in. were a muzzle-loader, and all our ordnance firing heavy charges are muzzle-loaders. The gun used in the Moncrieff experiments at Shoeburyness fired charges of 23 lbs. of powder. The cartridge of the breech-loader used weighed only 11 lbs. The actual force of recoil was, therefore, much less.

Yet, in spite of these advantages the gun only recoiled 2 ft. 4 in. at the first round, while the counterpoise moved but 1 ft. 3 in. How was this, since they were fastened together by a chain which could hardly have stretched? This chain had not stretched, but the india-rubber buffers had been somewhat crushed up. Clearly the recoil was not sufficient to drag the counterpoise through its grooves, while a lighter counterpoise would mean heavier work to the men who have to haul the gun up into its place after every round. The gun had not moved back as far as had been hoped by those responsible for the apparatus—not far enough to bring it within reach of the men to load. The force that should have been utilized in lifting the counterpoise must have been spent somewhere, but upon what? Partly in crushing the buffers, partly in destructive effect on the apparatus or its bed.

One more round was fired, and the experiment was brought to an abrupt conclusion. The recoil was violent, but short. The gun moved 2 ft. 10 in., and being checked there, transferred to its carriage and platform the force that should have driven itself backwards. The action of recoil, checked unscientifically, was instantly manifest. The gun, with its carriage, was seen to give a furious leap, like a savage beast trying to break its chain. It could not get free, for the chain was strong, but the dash downwards after the spring sent the whole elevating gear to the earth with a ringing fall, while the backward force separated the huge timbers of the bed, and caused the front trucks to jump off their racers and plunge some depth into the wood-work on which the racers were set. A horrible screaming sound was heard, and added to the effect upon the startled listeners; but it was due, not to any unknown damage, but to a motion of the air produced under certain conditions by the firing of heavy breech-loading guns. The piece was of no further use. It could neither be trained right and left nor elevated.

The experiment was made before the Moncrieff Committee, and we will venture to say that they and the other officers present were more impressed with the difficulties conquered by Captain Moncrieff than they had ever been before this negative experiment. The piece used on Friday was a comparatively light one, and its charge less than half the battering charge of a 7-in muzzle-loader, or about a quarter of that fired from the 9-in. gun. There was but one opinion—that such an apparatus was practically impossible for heavy guns.

We should not have noticed it but for the moral impression made upon the officers present. That impression found vent more than once in the words, "Thank heaven there is an end to experiments for the present." Suppose that instead of a failure the thing had been doubtful or even possible. There must have been rivalry set up at once between it and Moncrieff's inventions. The department charged by the British Government with the manufacture of carriages for heavy guns would have been divided against itself, at a moment when all men who have anything to do with the armaments of England should be working together in harmonious strength. The one thing now needful is prompt decision as to the guns, carriages, gunpowder, and small arms to be placed on British works or carried by British infantry. There is no golden age of arms, nor will final and perfect weapons be ever found. Is there to be found a workman of any sort, be he poet, artist, politician, or manufacturer, who has sent forth a single production of which he could say "It is altogether good"? There is a danger that while they are quarrelling and criticising, tinkering and polishing, Englishmen may find themselves suddenly thrust into war with forts half-built and wholly unarmed, commercial harbors undefended, the new infantry arm undecided, Militia untrained. Volunteers armed with muzzle-loading

rifles, and the military forces of the country half helpless for want of organization.

The manufacturing resources of this country are so great that material can be supplied as fast as called for, if only the pattern be decided, and careful supervision insisted upon. There is a great opportunity now for the officials at the War Office to show what stuff they are made of. Considering the present temper of the country there can surely be no difficulty about putting England in a full state of defence. The condition of France at this moment may teach us that days are of as much value in modern wars as months used to be.

SEWAGE PURIFICATON BY A B C.

From "Engineering."

Messrs. Sillar and Wigner's method of purifying sewage has, during the past two years, received an unwonted amount of publicity, and the "A B C process" is by this time tolerably familiar to most people, thanks to the extended trials it has received, and through the assistance of the public press, lay and professional, the latter being represented by "The Engineer," which a few months ago was loud in its praises. On May 27 that journal wrote *apropos* of the Hastings Sewage Works, after describing the effect of the process upon the sewage of that town: "We think this a complete and satisfactory proof of the great power of the A B C mixture to entirely deodorize the sewage. . . . We have no doubt that this simple process is capable of wide adoption throughout this country, as well as on the Continent," etc. Turning, however, to the number for August 12, we read, referring to the same subject, the following: "A mere glance at the evidence before us is more than enough to prove how inefficacious and crude is the A B C process. . . . There is scarcely one of these quack methods which some unfortunate local board or other has not been seduced into experimenting upon with the same results. . . . It is time these delusions were terminated," and so forth. These very contradictory assertions, the former of which almost treads upon the heels of the latter, would be sufficiently striking had they been printed in the columns of a daily paper. But appearing as they do in the pages of a periodical, whose motto is "Consistency in Journalism," the contradiction is worthy of inquiry, and it is quite time to attempt finding which of these statements is the true one, and we may be guided to a result by such evidence, unsatisfactory as it is, as can be obtained. When Messrs. Sillar and Wigner first brought their process into public notice, the novelty and sensational character of their proposition had possibly much to do with its early recognition; we were given to understand that the invention was principally the result of a study of the habits and customs of the Israelites, as set forth in the book of Deuteronomy, and that the inventors had drawn inspiration from that chronicle. An unknown and mysterious mixture, named from the initials of its three chief ingredients, on being cast into the sewage, seized instantly the impurities, and, changing their nature, precipitated them in flakes, until the water containing them was left, you were led to believe, pure and limpid. The solid matter, thus separated, was to be dried and sold at a high price for manure. At a recent Conversazione of Civil Engineers, we remember seeing collected a battery of bottles, containing samples of sewage from all parts of London, from Bayswater to Wapping. The exhibitor of these interesting specimens had, of course, on hand a stock of A B C, with which he constantly purified glasses full of the foul contents of the bottles aforesaid, and it was a sight to see him sipping the residual nectar in proof of his entire belief in the process. How many enthusiasts fell victims to this course of A B C we cannot say; but there is no doubt that their labors advanced the cause they had at heart, and which has been steadily gaining ground until the publication of a recent report of the Rivers' Pollution Prevention Commission, which has set its face dead against the process, whilst the Ha tings catastrophe of the other day at the new

works of the Native Guano Company has helped to accelerate the receding wave of public opinion.

Dr. Odling has placed the patentees in this predicament, that they must be content to remain under the imputation of having deliberately and systematically advocated a useless process, or that they must justify themselves by disproving Dr. Odling's strictures. This gentleman, in his recent evidence before the Rivers' Pollution Commission, stated his conviction that A B C was simply a "juggle." If he had said that the inventors of the process were deceiving themselves, he would have perhaps made a safer statement; for that this is the case there can remain no doubt after the careful official investigations that have recently been made. If we refer to one of Mr. Wigner's statements, which we published over his own name on the 10th July, 1868, it will be found that he relates in detail some careful experiments made with his process at Tottenham; from them we were led to believe that 85 per cent. of the ammonia, and all the phosphoric acid in the sewage, were precipitated, leaving rich and valuable manure containing 2.37 per cent. of ammonia, whilst the effluent water was nearly as pure as that of the Lea, the principal foreign matter being common salt which was discharged from a neighboring factory.

In the same volume of "Engineering," page 129, we published a further statement upon the responsibility of the inventors on the Leicester experiment. Here it was asserted that the effluent water was almost entirely purified, while the manure obtained was worth £4 a ton, containing as it did the most valuable fertilizing constituents, and that, upon the most moderate computation, a return of £160 a day could be relied upon from the sale of the manufactured guano.

It was about this time that the Rivers' Pollution Commission was employed in investigating the real merits of the system as applied at Leicester, and the results at which they arrived were utterly at variance with those hoped for by Messrs. Sillar and Wigner.

The process failed comparatively even in its strong point—that of purifying the water from suspended matter held in suspension. In a former report by the Commissioners it was recommended that the maximum amount of organic impurities held in suspension in sewage water upon its admission into any stream should not exceed 1 part in 100,000, whereas the Leicester water, after it had been submitted to the A B C process of purification, contained more than 3 parts in the same quantity. With regard to the influence of the A B C compound upon the sewage, the results were proved, by the Leamington experiments, to be still less satisfactory. The nitrogeneous organic matter held in solution is among one of the most active agents in river pollution, and we find that this is, under the most favorable circumstances, reduced only about 50 per cent. Passing over various subsequent experiments, conducted by the Commission, we arrive at one carried out by them upon the London sewage with the A B C mixture employed at Leamington. This was, it is true, only a laboratory experiment, but was equally conclusive with the others carried out in practice, and as it was found that in one case, at least, the

Description.	Dissolved Matters.							Suspended Matters.		
	Total solid matters left on evaporation.	Organic carbon.	Organic nitrogen.	Ammonia.	Nitrogen, as nitrites and nitrates.	Total combined nitrogen.	Chlorine.	Mineral.	Organic.	Total.
London sewage collected May 23, 1870	67.3	3.614	1.886	5 418	0	6.348	10.23	10.30	18.00	28.30
Ditto after treatment by A B C process	80.5	2.257	1.878	6.086	0	6 890	10.20	Traces	Traces	Traces

value of the Leamington tests was nullified by the fact that river water was freely admitted into the sewage tanks, the trial referred to is the more satisfactory. The sample of sewage having been mixed in the due proportion with the A B C compound, was allowed to subside, and after two hours the supernatant liquid was taken away and analyzed, an analysis of the sewage before treatment having also been made.

From this analysis it is shown that the total of soluble matter was increased by the addition of the mixture by 13.2 parts, that the organic carbon was reduced 37.5 per cent., that the organic nitrogen underwent no change, that the ammonia was increased, the excess being derived from the alum contained in the mixture, a minute proportion having been precipitated, and that the total combined nitrogen was increased by the action of the ammonia added. The effluent water, therefore, possessed a greater value as manure than the raw sewage.

On the other hand the precipitation was very satisfactory.

The utmost credit, then, that can be given to Messrs. Sillar and Wigner's process appears from these results to be that it may act as a tolerably complete precipitator, a result, however, which can be brought about by less costly means than they employ.

It is very difficult to understand how the inventors could have advanced such statements as those to which we have already referred, and which we first published two years since. It was, as we have said, asserted that 85 per cent. of the ammonia and all the phosphoric acid were precipitated, and upon this statement was based the commercial value of the process. That this statement is, to say the least, sanguine, we have now ample evidence to prove, as well also as the other confident assertion upon the market value of the dried residue, to be sold under the name of native guano, which we are told is worth £3 10s. per ton in the neighborhood of Leamington. The Commissioners' report upon this point is very complete, and until disproved we may assume it to be reliable. We give the analysis of samples taken at Leamington to be as follows :

Mineral matter	54.772
Organic and other volatile matters	45.228
Carbon	24.994
Phosphoric acid	.496
Total nitrogen	1.943
Ammonia	.185
Total nitrogen	2.36

Two very different estimates may be formed of the value of this residue, a theoretical and a practical estimate. In the former case, the market value of the different fertilizing elements being given, the theoretical worth of the manure is obtained. Thus with ammonia at £59 per ton, and superphosphate of lime at £32, the "native guano" should realize £1 13s. $0\frac{3}{4}$d. per ton. But experience has shown that a totally different result is arrived at in practice. The Leicester sewage, treated with lime, gave a theoretical value of from 15s. to 17s. per ton, yet 1s. per ton only was its selling price. We do not necessarily infer, nor, we believe, would the Rivers' Pollution Commissioners assert, that the A B C products must suffer a proportionate depreciation ; but there can be little doubt that a wide difference exists between the price based upon chemical composition and the actual amount the manure will realize. Assuming, however, for a moment, that £1 13s. $0\frac{3}{4}$d. is not an excessive figure, it then remains to be seen at what cost the native guano is produced. And here we take, again, the results obtained by the Commissioners, and published by them in their report. Taking the work of one day at Leamington, we find that 2,523,520 lbs. of sewage were treated by the "A B C" in $8\frac{1}{2}$ hours ; therefrom resulted 1,052 lbs. of mud retained in the tanks, or $\frac{5}{6}$ths of the total matters held in suspension by the sewage. To precipitate this quantity, 1,834 lbs. of "A B C" were added, of which 1,201 lbs. were arrested with the sewage deposit, the remainder having been swept away, for the most part in solution, with the effluent water. There remained, therefore, 2,253 lbs. of solid matter. To this weight 7.46 per cent. should be added to bring the manure to its exact condition as an article of commerce, that proportion of water being contained in it. We thus get a total of 2,435 lbs., the theoretical value of which, calculated upon the basis before given, is £1 14s. 9d.

Now the actual value of the material used in precipitating the 1,052 lbs. of sewage was £1 18s. 5d., a portion of which

was not lost, being retained in the 1,201 lbs. of A B C recovered. The fertilizing value of this quantity is theoretically 11s. 7d., leaving the assumed value of sewage obtained £1 3s. 2d. But to gain this result we have seen that a sum considerably larger was necessarily expended, and to this of course have to be added the expenses of labor, the deterioration of plant, the cost of working the same, and the interest on capital employed. And, of course, when we bring the market value of the manure to practical figures, the loss will be vastly increased. With regard to this actual value it is somewhat difficult to arrive at absolute conclusions. Compared with Peruvian guano, or superphosphate manure, the "native guano" stands thus :

Ingredients per 100 parts.	A B C Manure.	Superphosphate.	Peruvian guano.
Combined nitrogen	1.695	.40	14
Equal to ammonia	2.050	.50	17
Phosphoric acid, equal soluble phosphate of lime	3.26	26.00	7
Neutral phosphate of lime	..	10.00	22
Soda salts	..	..	8
Potash	..	..	

The small proportion of fertilizing material which, according to these analyses, the A B C manure possesses, would necessitate the application upon land, of a proportionately larger quantity than either of the other two, these proportions in fact being as 160 to 55 of the one and 20 of the other. Independently of the cost of transport and the delay, and expense, and inconvenience of spreading such an excess of fertilizing material over the soil, it would appear from evidence, and upon the test of experience, that the important elements of manure are greatly reduced when mixed with a large quantity of useless matter, and it is this useless matter that agriculturists are called upon to purchase at a considerable price. The only inference to be gathered, then, from the investigations to which we have referred is, that, by a costly and as yet an imperfect process, an inferior and dirt-encumbered manure is produced, the value of which is less than that of the precipitant employed. And, as a natural consequence, the effluent water which is passed off afterthe precipitation, is heavily charged, not only with impurities injurious to any river purification, but containing also the most active elements of fertilization, as well as valuable component parts of the compound employed for the separation of the "native guano." These results, falling short of the first sanguine anticipations of the advocates of this system, have probably led to the recent suggestion that, by a judicious combination of dry manure and sewage irrigation, the golden mean could be struck, and the very perfection of sewage utilization attained. But so long as we have the facts before us which have been so clearly put forward in the report to which we referred, there seems to be no way of avoiding this difficulty, that an extreme cost is required to separate the solid from the liquid portion, and until some sufficiently cheap method be devised, it would be simply impossible, with any regard to economy, to go through so much to gain so little, to precipitate at such a sacrifice a small proportion of the whole. We do not say that there is no practical merit in Messrs. Sillar and Wigner's system, but the arguments advanced against it in its present form of working are so overwhelming, that the advocates of the process will either have to disprove them conclusively in every detail, or will be forced upon the admission that they have yet to learn the real A B C of sewage ventilation.

Triangular Drawing-Board.—Mr. Geo. Fawcus, of North Shields, England, has contrived an equilateral triangular drawing-board for isometrical drawing. An ordinary T square applied on the edges of an equilateral triangle draws tangents that meet each other at angles of 120°, and other lines drawn parallel to these radiating ones form with them angles of 60° and 120°, which are the exact angles of the apparent squares of isometrical cubes. The inventor believes that the use of this new drawing-board will make the teaching of isometrical drawing both simple and easy. The practice of isometrical drawing is strongly urged in the science and art drawing classes.—*Nature.*

BREECH-LOADERS FOR ENGLAND.

From "The Mechanics' Magazine."

Now that the bloodless battle of the breech-loaders at Wimbledon is over, the attention of the country is turned to the selection of a weapon for England's army which shall in turn replace the Snider, and during the recess a good opportunity is afforded for reviewing the results attained by the last Wimbledon breech-loading competition. Before another session shall have been brought to a close it is quite probable that the Select Committee and the Government will have decided upon the weapon of the future. Of the many rifles which have been introduced to the public at Wimbledon, those invented by Messrs. Henry, Soper, Westley-Richards, and Martini, the result of the last three years' competition has proved that these men only are in the front rank as producers of a breech-loader, and on the rifles of these inventors we now propose to make some few remarks. In the first place, it may be interesting for our readers to fully understand the nature of the breech and lock mechanisms of these four rifles, and for the purpose we give an accurate description of each rifle, which we hope will be comprehensible to non-scientific as well as scientific readers. It will be seen that in the construction of the breech and block mechanisms there are fewest pieces in the Soper and Westley-Richards rifles, while in the Henry rifle there are more than double the number. Moreover, the Soper rifle has a side lever, which can be pressed immediately the shot is fired, while in the case of the other 3 rifles the hand has to be carried under the rifle for the purpose of pressing forward the lever to open the breech each time the shot is ejected. To the Henry rifle is attached a cock similar to the Enfield, which necessitates the use of both hands in rapid firing. This would be a great disadvantage to a soldier in warfare, for it is evident that in whatever position he may be he must have one hand with which to hold the rifle.

The Henry rifle, pure and simple, contains in the lock and breech action complete 46 pieces—23 pins or screws, 6 springs (2 of which are spiral), and 17 other pieces. The stock is in two parts. The principle of the rifle is that the breech-block is operated upon by a lever pivoted at the bottom of the breech, and moves freely up and down in a slot, and vertically through the breech shoe. The old pattern back-action lock is retained in this rifle, which necessitates a separate action in cocking, thereby preventing that rapid firing which has been attained by other rifles, excepting when the rifle is secured by straps and other contrivances which admit of the firer using both hands in loading and firing, as in the case of Messrs. Farquharson at the late Wimbledon competition.

The distinguishing feature in the Martini is the unusual length of the breech shoe, which is made to admit of what is termed a drop-action breech-block pivoted near in line with the top of the cartridge, so that when the block is lowered the whole case can be ejected and the new cartridge inserted in an oblique direction. The block contains within itself the plunger or striker, which is operated upon by a spiral spring. The breech-block is worked by means of a lever pivoted or mounted on a trigger guard held in its place by a spring. The lowering of this lever depresses the breech-block, and acts upon the extractor. When the lever is returned to its place, it forms a bow like a second guard, which is found very much in the way when the rifle is required to be used with a bayonet. The breech and lock action and fixing for the same consists of 27 pieces, four of which are springs, the mainspring itself being the ordinary spiral spring coiled round the striker, which readily accounts for the great number of misfires which occur with this rifle. The stock is in two pieces, and is pronounced by the Select Committee to be very weak.

The third rifle now prominently before the public is the Soper rifle. The chief feature of the Soper direct-action rifle is that the lever is mounted on the right side of the rifle in the place of the ordinary cock, and so conveniently arranged that it can be immediately depressed on the firing of the rifle. The depression of this lever forces back the striker, raises the breech, cocks the gun, and ejects the cartridge. The breech-block is pivoted

on the right side similar to the Snider. The lock action is identical with the Enfield in principle, and so arranged that the cock strikes a blow in the centre of the rifle in line with the axis of the bore. The cock is connected by a swivel to the ordinary mainspring taken from the Enfield. This arrangement insures a certain blow being struck on the cap, and at once accounts for the fact that no misfires occurred at the Wimbledon meeting when the new Government cartridge was used. The lock and breech action consists of 17 pieces—2 springs, neither of which are spiral, 3 screws, and 1 pin. The stock is in one piece and exceedingly strong ; the lock has the ordinary half-cock, at which position it can be loaded. It is also furnished with the ordinary snap cap, which is used with the Enfield rifle, an advantage not possessed by the other rifles, but which is of the greatest importance in a military gun.

The Westley-Richards rifle is similar in construction to the Martini, with the exception of the spiral spring, which in the Westley-Richards is disposed of, the V-pattern spring being used instead. In some of the rifles the stock is in one piece ; one or two good scores were made by this arm at the late Wimbledon meeting. From its peculiar construction it is not well adapted for the present Government cartridge, as the striker has no other support but one mainspring, and is therefore unable to be driven backward, and the hole in the breech-block filled with the cap from the cartridge, which would at once block the rifle and prevents its action. A special cartridge is therefore obliged to be used which is not liable to this particular mishap.

It was noticeable at Wimbledon this year that many of the best Wimbledon shots, including Sir Charles Shakerly, Mr. Edward Ross, and Mr. Dunlop fired the Martini rifle during the first week, and most signally failed. It was in the second week of the trial that the competition got exceedingly warm, and when the Henry and Soper rifles in turn gained popularity. Such men as Sir Charles Shakerly and Mr. Dunlop, who had failed with the Martini gun the first week, now went in and made winning scores with the Soper rifle. It is needless for us to recapitulate the events which marked the proceedings of the second week's competition at Wimbledon. It has already been stated that the Soper rifle made some of its best scores in the presence of Lord Elcho and members of the Government, and the result of the whole fortnight's competition has shown that out of the ten best scores made for the Bass prizes eight of them were made by the Soper rifle, while at the 500 yards more than half the nine scores were made by this rifle. These scores have been examined by Captain St. John Mildmay, and published in the "Volunteer Gazette" of August 6, 1870. We now have the reports of the Select Committee on the Government rifle before us, and, judging from their unsatisfactory nature, we have little doubt but that the Government will be induced to reconsider the question of the future military gun before they proceed with their manufacture. The simplicity of action and the strength of the arm must be a great desideratum in a military breech-loader; and after all that has been written there are many other questions to be considered besides rapidity of fire. The general construction of the arm as a military gun is of vital importance, and it would be most unwise to place such an intricate piece of mechanism as the Martini in its present condition in the hands of a common soldier. What is now required is the appointment of a committee of mechanics, who shall examine and report to the Select Committee on the principles of the four rifles which have proved themselves in competition at Wimbledon with the rifles of the world to be worthy of the notice of the Government. There should be no favor shown, but an impartial report and a fair trial for all.

Two competing submarine cable companies, the China Submarine and the Great Northern and China Extension, have agreed to work together and divide receipts. The lines from Singapore to Japan are to be finished before the end of 1872. The combination is for 30 years.

The new elevator of the Milwaukee and St. Paul Railway Company, at La Crosse, has capacity to store 125,000 bushels of grain, and to transfer from barge to car 5,000 bushels per hour. It has a 100-horse power engine.

ON SOLUBLE GLASS.

By PROF. CHARLES A. JOY.

From "The Journal of Applied Chemistry."

The value of this article for many purposes in the arts, and the want of a popular knowledge of its properties and uses, induces us to compile from the best sources the following paper on the subject, in the preparation of which we shall avail ourselves more particularly of the reports of Professor Wagner on chemical technology, and of the learned researches of Fuchs and Kuhlman,

Soluble glass, called also water glass, liquid quartz, liquid silex, silicate of soda or potash, was accidentally discovered by the late Professor Fuchs, of Munich, in the year 1818, in the course of some investigations he was making for the preparation of pure silica. He became more familiar with its properties in 1820 and learned how to prepare it by the solution of silica in caustic potash. Afterward he studied the subject thoroughly, and became acquainted with all its properties and its uses. In the year 1823, as the theatre in Munich which had been destroyed by fire, entailing great loss of life and property, was rebuilding, the Government requested a scientific commission to search for an agent that would render the woodwork and stage appointments incombustible. Professor Fuchs, in association with Dr. Pettenkofer, at once instituted numerous experiments upon soluble glass as the best agent for this purpose, and the conclusions at which they arrived have been fully confirmed by the subsequent studies and experience of other men. In 1826 soluble glass was manufactured in Augsburg on a large scale, and sold at the rate of 25 florins the 110 pounds. From this time forward a knowledge of the new compound became disseminated, and new uses were constantly suggested for it.

According to Professor Fuchs there are four kinds of soluble glass:

1. Potash glass.
2. Soda glass.
3. Potash and soda glass (combined).
4. Glazing glass.

Potash soluble glass is prepared by fusing together:

45 lbs. of quartz.
30 lbs. of potash.
3 lbs. of charcoal in powder, and digesting the fused and pulverized mass in water.

Soda soluble is composed of:

45 lbs. quartz,
23 lbs. calcined soda.
3 lbs. charcoal.

Or, according to Buchner, more economically of:

100 lbs. quartz,
60 lbs. calcined glauber salt,
15 to 20 lbs. coal.

There are several ways of making the third variety of combined soda and potash soluble glass. By fusing seignette salt (tartrate of potash and soda) with quartz; by employing equal equivalents of nitre or Chili saltpetre and quartz; fusing cream of tartar, Chili nitre and quartz; or by melting at once:

100 lbs. quartz,
28 lbs. purified potash,
22 lbs. calcined soda,
6 lbs. charcoal powder.

For technical application it is possible to mix three volumes of a concentrated potash glass solution and two volumes of a soda glass solution.

The fourth variety, called glazing or fixing glass, is made by mixing perfectly saturated potash glass with soda glass, and is used for producing fast colors in stereochromy and fresco painting.

There is also a wet way for the manufacture of soluble glass, which consists in dissolving flint stones in concentrated soda lye in iron boilers under 7 or 8 atmospheres of pressure, and for this purpose infusorial silica or tripoli is also especially adapted. The tripoli is first calcined to destroy all organic matter and then introduced into boiling soda lye of 1.5 specific gravity or potash lye of 1.135, and afterward clarified by a little water lime and evaporated to the required consistency. As soluble glass readily absorbs carbonic acid, it must be kept in closely stopped packages. The strength of the solution is estimated in degrees founded upon the package of dry powder dissolved in the water; 33 deg. means 33 parts dry glass and 67 parts water; 40 deg.=60 parts of water and 40 parts of soluble glass. In applying this solution to wood-work, roofs,

fabrics, porous stones, etc., it is necessary to begin with a weak solution and to wait until it is thoroughly dry before putting on a second coat. The second application can be considerably more concentrated than the first. It will not adhere to freshly painted surfaces, but when the oil is thoroughly dry and changed in the sunlight, the water glass can be used with impunity. Care must be observed to wash out the brush thoroughly after use, to prevent its hardening to stone. Soluble glass protects wood from the influence of fire, water, and the atmosphere. The surface of wood is covered with glass, and not only will not take fire, but is less liable to decay. Some varieties of wood are apt to be discolored by the solution; oak and beech are the least affected. As the soluble glass when applied to wood serves a purpose analogous to a varnished surface, it is necessary to avoid a too concentrated liquid, as otherwise it is liable to scale off. One pound of 33 deg. solution, diluted with five pounds of water, is found to cover wood very well. Wood, paper, linen and straw, when covered with several coats of soluble glass, are no longer inflammable, but simply char when exposed to fire. A coaitng of glass also prevents the decay and rotting of wood, and keeps out worms. Beer barrels, butter firkins, and milk tubs can be easily kept clean when painted with soluble glass, and the same is true of vessels designed to hold sugars, syrups, wines, petroleum, etc. The most important use of soluble glass is its application to surfaces of stone and mortar. For this purpose it is necessary to impregnate the surface with a solution composed of one part 33 deg. and 3 parts rain water. For this purpose a powerful pump or syringe, with a spout like a watering-pot, is used for injecting the liquid, in the form of syrup, into the pores of the stone or mortar. The surfaces thus prepared are in condition to receive the further coating of liquid quartz.

Mortar and porous limestones react upon the soluble glass, producing carbonate of lime, hydrate of lime, and, ultimately, silicate of lime, which thus presents an impervious vitreous surface, capable of resisting the action of moisture and the atmosphere, and is in a proper state for fresco painting in mineral colors. Organic colors are apt to be destroyed by the alkali of the soluble glass, and hence, for fresco painting, mineral paints are alone available. A second coating of paint, rubbed up with soluble glass, is usually sufficient for all practical purposes, and a wall thus treated can be washed with soap and water, and kept thoroughly clean. A plain, white color is obtained by mixing chalk with soluble glass. Zinc white and silicate of soda set so rapidly that it is necessary to add $\frac{1}{4}$ to $\frac{1}{2}$ its weight of precipitated sulphate of baryta before applying the color. Baryta white and soluble glass also afford a good, fast color. Fluor spar with pulverized glass and soluble glass also gives an exceedingly solid mass. The pigments that have been found by experience to serve the best purpose are chromate of zinc, sulphide of cadmium, blue and green ultramarine, schweinfurth green, oxide of cinnabar, etc. Prussian blue and colors prepared from it and chromate of lead, chromium, will not answer, as they are destroyed by the alkali, the same as organic colors. It is well known that the fresco painting in the Capitol at Washington, in the new museums in Berlin and Munich, are done with water glass, and the success in their use is complete.

Soluble glass, with or without colors, adheres closely to such metals as iron, zinc and brass, and protects them from the influences of the air and water. It has been found that when stoves are painted with a mixture of soluble glass and black oxide of manganese, a species of flux is produced by the heat, which does not scale off, but thoroughly protects the iron from any corroding action Plate glass, when coated with the soluble silicate, becomes opaque, and when baryta is mixed with the liquid quartz it assumes a fine, white appearance. If the glass be heated it becomes enamelled, like porcelain, and fixed colors, such as ultramarine and oxide of chromium, open up an extensive application for soluble glass for transparencies, church windows, etc. The manufacture of artificial building stone by means of soluble glass has been conducted in Germany and England on an extensive scale. In Vienna, barracks of an enormous size have been constructed of such artificial stone, and the tower of the Cathedral in that city was put into thorough repair in the only way that was possible, considering the great height of the tower and the extent to which it had fallen into decay.

When ground chalk or marble is stirred into a paste with soluble glass, the mass

becomes so hard that it can be employed for building purposes, or for the restoration of decayed stone structures.

Marble and dolomite immersed in a solution of soluble glass, and the operation repeated a number of times, take up an appreciable quantity of silica and become so hard that they are capable of taking a fine polish. Attempts to employ such stones for lithography have been made, but not altogether with success. Artificial stone can be prepared as follows:

Well washed and gently heated sand is stirred into a warm solution of soluble glass until a proper consistence has been reached for pouring it into a mould. After it has set it is removed from the frame, which ought to have been previously oiled, and is left to dry in an airy place. To avoid too great a consumption of water glass, a stone or brick can be put in the centre of the mould. It is also possible to stir in pebbles and to use earthy colors in imitation of marble and conglomerate. Such artificial material becomes very hard, and is adapted to pavements, hearths, and building purposes.

Soluble glass can be used in the manufacture of paper-hangings, for printing on paper and woven fabrics, for attaching gold and silver powder to any kind of object.

Hydraulic lime can be prepared by mixing in fine powder 10 to 12 parts by weight of dry soluble glass and 100 parts of lime —this affords a ready way of preparing a hydraulic cement from ordinary lime, which is always available.

One of the earliest and best known uses of soluble glass is as a cement for glass, porcelain and metals. It is put up in small packages for this purpose, and sold on the corners of streets under various names. Pieces of glass or porcelain cemented in this way will break more readily in places which were whole than where they were repaired. The solution ought to be quite concentrated when employed for this purpose. The fragments to be repaired must be heated to the boiling point of water, and both surfaces be then moistened with the cement and pressed closely together and held in position by a strong cord, and left to dry in a warm place. By mixing sulphate of magnesia or calcined magnesia and soluble glass, a cement can be formed that can be cast into moulds, and very generally be substituted for meerschaum.

Soluble glass has been used in restoring several European churches, also the Houses of Parliament in London.

Wood and timber and other porous substances, after being boiled for several hours in soluble glass, then exposed in tanks containing lime water or chloride of calcium and magnesia, and left to dry, become highly vitrified and incombustible. Railroad ties, ship's timber, house and bridge beams, have been treated in this manner with entire success.

The silicate is also used for penetrating fire brick and clay, and for cementing the walls of furnaces.

When stirred up with chloride of calcium and used for luting down the covers of crucibles, it answers an excellent purpose.

Repeated attempts have been made to use soluble glass as a substitute for soap, as well as for adulterating soap; but the reports of a commission in Prussia, where trial was made at the State's prison of Spandau, was unfavorable. The detergent properties of the silicate are not very great, and it cannot be recommended, excepting in a few cases where grease is to be removed from the fleece of wool, or some similar cleansing is to be performed.

As a species of lubricator, and to preserve the elasticity of leather, soluble glass has a ready application.

We have thus compiled from various sources, and have put together from our own knowledge and experience, some of the leading facts in reference to soluble glass. It is somewhat remarkable that an article of so much value in manufactures, and capable of such extensive use in the arts, should be so little known and so rarely applied. And it is for this reason that we have devoted so much space to its consideration.

STRET CAR "MAN CATCHER."—Mr. U. B. Vidal, of Philadelphia, proposes to provide the street-cars with strong skirts or nets, supported on frames to extend from the flooring down to or near the ground. The object of the improvement is to save persons who fall from being run over by the car. The frame which supports the net is to be elastic, vertically, so as to yield when any portion touches the ground.

PRINCIPLES OF TRACTIVE POWER IN LOCOMOTIVES.

By P. BARNES, Jr.

From "The Railroad Gazette."

The power of any locomotive is limited by the *friction*, or resistance to slipping or sliding between the tread of the driving wheel and the rail. The word "adhesion" is sometimes used in this connection, but it can be applied with correctness only to a resistance like that which is offered to the shearing of a body, as a bar of iron, in which the particles of the metal are forced to move or slide upon themselves while the shearing is taking place. Hence the ability of an engine to move a load will depend upon *the weight resting upon its driving wheels and the condition of the surface of the rail*, because the most careful special experiments and extended observation in practice show that, in common with metals so nearly similar in character as rails and tires, whether of iron or steel, the friction is almost exactly proportional to the perpendicular pressure between the surfaces, or, in the case of the locomotive, to the pressure upon the rail. It is by this friction that the wheel is prevented from revolving freely when pressure is brought upon the piston, and this friction is always greatest, and the engine can draw the heaviest loads, when the rail is either perfectly dry or perfectly wet, so that the surface of the tire may come into close contact with the surface of the rail without the intervention of any slippery film of moisture.

The general law, deduced from the most exact experiments, is that the force required to move one body when sliding upon another corresponds very nearly to the perpendicular pressure between them multiplied by the *coefficient of friction.* This coefficient is simply the relation or proportion which the pressure required to move a body upon any surface bears to the weight of the body itself, and for general purposes may be stated to be from 1-20 to 1-10 between metals when properly oiled. If the surfaces are not properly smoothed, or if the pressure between them is so great as to produce grinding or abrasion, then this law will not hold good, but the coefficient will increase rapidly to a point determined by the special condition of the case. It is also evident that this condition or proportion will diminish when the surface sustaining the weight of the rail, in the case of the locomotive, becomes more slippery than usual, as when snow or ice accumulate on the track, or sometimes during a slight rain, and hence, as is well known, the tractive force of any engine may be very greatly reduced at such a time.

Since, then, the power of a locomotive depends so entirely, other things being equal, upon the weight carried upon its driving wheels, it might seem necessary merely to increase the total weight of the engine by loading it with pig-iron in order to increase its tractive powers; but further consideration will show that this is not true. To illustrate the actual state of the case, suppose a locomotive to be firmly attached to a solid rock which cannot be moved. If steam be then admitted to the cylinders, a pressure will be brought upon the driving wheels tending to make them revolve, and in this supposed case they can only slip upon the rail. This slipping will always take place when the pressure upon the piston due to the steam within the cylinder is greater than the product of the weight of the engine multiplied by the coefficient of friction, since, as has already been shown, there is no other means than this of holdng the wheels to the rail. Slipping will not occur in this case if the pressure upon the piston is less than the product of these two factors. If the weight of the engine be not great enough to prevent slipping for any given size of cylinder or pressure of steam, then an increase of weight may usefully be made, so that this product may be increased, by which, as has been shown, the tractive power of the engine is measured or limited.

It will be seen, then, that with any given size of cylinder and standard pressure of steam a certain weight must be given to the locomotive, so that, under ordinary circumstances of weather, etc., no slipping of the wheels may occur, and also that no useful result can be obtained by increasing this weight beyond this certain amount; for the pressure upon the pistons cannot be increased beyond this assumed

limit, and hence no additional load can be drawn, even though no slipping should take place.

The objection urged against the use of six-coupled engines, that they have a long rigid wheel base, is an important one, and it is receiving serious attention in England, where these engines are vastly more common than in this country. Few builders, however, would put three pairs of driving wheels under any engine without making the boiler and other parts longer or heavier, so as to furnish a weight to be borne upon each pair of wheels equal, or nearly so, to that borne by each pair of wheels of an ordinary four-coupled engine, so that the larger engine may be efficient just in proportion to its size.

The grand objection to any increase of the weight of our engines, as now constructed, is that it is too destructive to the track to load each pair of wheels even as heavily as is ordinary now. The blows dealt by passing wheels upon the rail joints, and the bending or breaking strain brought at any instant upon the joint in the rail where a wheel presses, depend upon the weight which the wheel carries as well as the speed at which it moves, and hence to diminish our track repairs, that which is nearly or quite the most greedy of all maintenance accounts, the load borne per wheel in our locomotives must be lessened at least one-half, so that it may more nearly agree with the load borne per wheel in the cars. How this can be done without increasing the rigid wheel base, while the present boiler and cylinder capacity are retained, is one of the most trying problems of the present day among locomotive builders, and certainly the most promising commencement of its solution is the introduction of the Fairlie engine, notwithstanding the numerous complications with which it is still beset.

HISTORIC METROLOGY.

From "Engineering."

All systems of weights and measures of the present day are but the *debris* of what was once an elaborate and highly-finished system, and can all be traced back to times preceding any known work of man, except it be the division of the zodiac and classification of the stars, to one original system, as distinctly as languages can all be traced back to one primitive language. Exceptions of course occur. It is not, therefore, surprising to find that weights and measures, instead of being based on arbitrary and whimsical standards, as the world is taught, such as the length of some man's arm or foot, are based on standards taken from nature.

Of these standards the circumference and surface of the earth have been adopted for land and itinerary measures. For weights and other measures the most important units are the ordinary sized barleycorn, the large barleycorn, and the corresponding *abercorn*, or ordinary sized water grain, known in England as the troy grain, in Egypt as the habbah and the large abercorn.

The circumference of the earth, for times before the creation of the world, according to orthodox teaching, was fixed at 25,000 English statute miles, and this fact has ever since been more or less known (John Fernel, it would seem, was one of the inheritors of the knowledge), and the surface was represented by a parallelogram of two squares, each of 10,000 statute miles in length.* This parallelogram was divided, both lengthwise and broadwise, similarly to the circumference, into 360 deg., and each degree again into 60 parts or miles.

The mile thus obtained lengthwise ($4,888\frac{8}{9}$ English feet) is the old Roman mile, of which so much has been written, and so many conjectures hazarded ; and the old Roman foot was the 1–5000th part of this mile (11.7333 English inches), differing only 1–100th of an inch from the Roman foot of the present day. One-tenth of $4,888\frac{8}{9}$ English feet is the exact vertical height of the Great Pyramid.

Of the units specified, the abercorn, or ordinary sized water grain, is a weight equal to the weight of a mass of water of the bulk of the ordinary sized barleycorn, and the relative weights of the several units are in the ratio of the numbers 8, 9,

* These dimensions are based on the supposition that the ratio of the diameter to the circumference is as 32 to 100.

$10\frac{2}{3}$, 12, correponding to the fourth, fifth, and major tone of the musical scale.*

The weight of the barleycorn is therefore three-quarters the weight of the abercorn, and 3 abercorns are equal in weight to 4 barleycorns. Hence the word "troy," which, as Lord Swinton surmised, is a corrupt pronunciation of the French word *trois*.

The size of the barleycorn and of every grain—and in this statement the key to the whole mystery of weights and measures is contained—is the length of the side of a cube of water of the weight of the grain; and from information afforded by the pyramids of Gyzeh, the bulk of the ordinary sized barleycorn was fixed such that $333\frac{1}{3}$ barleycorns were contained in $\left(\frac{6944\frac{4}{9}}{6912}\right)^3$ English inch, and the formula $12^5 \times 10^3 \times 44$ expressed the numbers of barleycorns equal to the circumference of the earth.

From standard measures still existing it would appear that the size of the barleycorn was subsequently modified, and 1,000 barleycorns were made equal in bulk to three cubic English inches, and the length of the barleycorn consequently reduced to $\sqrt[3]{\frac{3}{10}}$ English inch. In the first instance, the weight of water was determined at 248.12 troy grains per cubic English inch, and in the other to 250 troy grains.

Another modification took place, for the sake of harmony and relationship, by which the length of the barleycorn was again reduced to $\frac{12^2}{10^2}$ English inch, and for the same reason the relative lengths of the barleycorn and water grain measures were generally assumed to be as 10 is to 11, instead of as the $\sqrt{3}$ is to $\sqrt[3]{4}$.

These modifications, which doubtless took place at intervals far apart, seen through the long course of ages that have transpired since they were adopted, appear to merge all into one system, and tend much to complicate the subject. By these changes alone three different standards are obtained for every measure.

By the last specified system the size of the ordinary barleycorn was fixed at .144 English inch; according to Kelly this is the exact length of the Chinese *hoon;* the size of the large barleycorn at .15 English inch; the size of the water grain at .1584 English inch; and the size of the large water grain at .165 English inch.

It is worthy of remark that, from experiments that have been made, these results agree with the absolute thickness or diameter of barleycorns of the present day. Thirty-three of the largest barleycorns that could be procured, placed side by side, measured on an average .154 English inch each. The cubit consisted of 144 grains, consequently the barleycorn cubit was 20.736 English inches long, exactly $\frac{1}{2}$ the length of the double cubit measure found embedded in the walls of the palace of Karnac, and now deposited in the British Museum, where it may be seen—wonderful to relate—as round and fresh as it was the day it was made, although probably some 3,000 or 4,000 years have since elapsed; the large barleycorn cubit was 21.6 English inches, still preserved at Florence, Mentz, and many other places; the water grain cubit was 22.8096 English inches long, and the large water grain cubit was 23.76 English inches long.

It would be quite impossible, even if it were desirable, to write an essay on weights and measures in form of a letter, and therefore the few observations that follow will be confined to connecting the previous statements with existing systems of weights and measures.

For reasons not clearly discernible, at some early period or other new systems of weights and measures were introduced, the measures of which were just $\frac{5}{6}$th the length of the measures previously existing, and the weights were to the old weights in the ratio of 5^3 to 6^3.

Now $\frac{5}{6}$th the large barleycorn measures formed the *Olympic* measures, of which the English foot and yard, the Bombay covid, the Bengal cubit, the Madras covid, the Guinea jactan, the Malay hastah, are among the remnants. Five-sixths the large water grain measures formed what Hero* denominates the *Philœtarian* measures. Of these the English furlong, mile, acre, are modern examples, and the English ton weight is the weight of the cubed

* Another important unit it is well not to pass unnoticed was the grain, equal in weight to 1 1-9th troy grain

* Hero was a mathematician of celebrity, and wrote a work concerning metrology, fragments of which have descended to modern days, he lived, it is supposed, in the third century B. C.

Philœtarian yard of pure water. The Philœtarian yard (39.6 English inches) is also the 1-10,000,000 of the quadrant of a meridian of 25,000 English statute miles, and is also the length of a pendulum vibrating astronomical seconds $\left(\frac{365.24}{360}\right.$ ordinary second), on the supposition that the force of gravity is 384 English inches; (the number 384, it is to be remembered, is, as Plato says, the first of unities); and that the ratio of the diameter to the circumference is as 32 is to 100—a ratio that wonderfully simplifies all calculations connected with the sphere, and which there is reason to believe was adopted by ancient inhabitants of the world.

It will be observed that the Philœtarian and Olympic systems are corresponding measures; the cubed Philœtarian foot of grain, the Hebrew epha, being equal in weight to the cubed Olympic foot of water, the Hebrew bath.

Five-sixths the ordinary barleycorn, and $\frac{5}{6}$ths the ordinary water grain measures, are measures of equal repute to those that have been named, and constitute some of the principal measures of the present day, but must be left without further notice. It may, however, be observed that $\frac{5}{6}$ths the ordinary barleycorn cubit is $\frac{1}{2}$ the length of the side of a cube of water of 2,000 old Roman litras (5,184 troy grains); $\frac{5}{6}$ths the large barleycorn cubit is $\frac{1}{2}$ the length of the side of a cube of water of 2,000 old pounds of 5,832 troy grains, still preserved at Warsaw and Alexandria, and is the pound that was introduced into France by Charlemagne. Five-sixths the ordinary water grain cubit is $\frac{1}{2}$ the length of the side of a cube of water of 2 000 Egyptian ratels (6,912 troy grains), and $\frac{5}{6}$ths the large water grain cubit is $\frac{1}{2}$ the length of a cube of water of 2,000 lbs. of 7,776 troy grains, the proper weight, it is believed, of the French pound—*poid de marc*—preserved unimpaired at Oran and Tunis. Twice 7,776 troy grains is the weight of a cube of water $\frac{1}{10}$th the length of the Philœtarian yard, and the cubed Philœtarian yard is, as has been previously observed, the weight of the English ton. In the above examples the weight of water has been assumed 250 troy grains per cubic English inch.

To dispel any lingering doubts as to existing weights and measures having proceeded from one ancient universal system, a few more facts will be mentioned.

In Ceylon, not only the long measures, but, what is a strange coincidence, the land measures are the same as in England. In India, north, south, east and west, the English cubit is a native measure, and is also found among the Chinese and Malay measures. The Madras land measure, the Cawney, the Malay land measure, the Orlong, the Coptic Feddan, are all one and the same measure, and consist of 4,000 square ordinary water grain yards. The Indian biggah is exactly $\frac{1}{4}$th this measure. The Swedish tunneland and the saccata of Florence are identical measures. The toch of Vienna and the Lisbon acre each consist of 4,000 square large water grain yards, and the examples could be greatly multiplied. The English acre consists of 4,000 square Philœtarian yards, as has been before alluded to. Unless weights and measures have originated from one source, how are these facts to be accounted for? How is it that different nations of different races, scattered over the face of the earth, possess the same standard measures? It cannot be ascribed to chance, and to suppose that they have been introduced with colonization is as reasonable as to believe that the English and other European words to be found in Sanscrit dictionaries owe their position there to the same agency.

I had intended to have entered more fully into the construction of English weights and measures, once held sacred and preserved among holy things, now debased among the lowly; but I fear this letter has already extended to too great a length, and I will therefore only add one further fact to show the antiquity of English measures and the insubordinate nature of weights and measures generally.

By the statutes of the realm, from the earliest Norman days, the weight of the quarter was declared to be 512 troy lbs. This measure is an old Hindoo measure found specified in Sanscrit works, but there is no standard measure or other evidence existing to show that it was ever adopted in England.

The English quarter of water is, and seemingly always has been, equal in weight to 777$\frac{7}{9}$ troy pounds. The quarter of grain is a less definable measure, and there is no knowing what it is. Four

quarters of water ($311\frac{4}{9}$ troy pounds) is exactly the weight of a cube of water whose side is the length of the double barleycorn cubit of 144 barleycorns $\sqrt[3]{\frac{3}{10}}$ English inches long, weight of water being 250 troy grains per cubic English inch, and in capacity is equal to the contents of the stone chest of the Great Pyramid. Should any of the foregoing statements be questioned I shall be ready to bring up reasons to their support.

THE METALS AND THEIR ORES.

By EDWARD GLEDHILL.

From "The Mining Journal."

In the present paper it is my intention to explain—firstly, the method of ascertaining the specific gravity of solids when in broken or crushed fragments; and secondly, to show how the knowledge thus obtained may be applied to a useful and practical purpose by the miner or ore-washer, by enabling him to judge, with almost absolute certainty and exactitude, whether or not the various parcels of ore he may be preparing for market are cleansed from their associated matrix and gangue, and brought to their requisite standard of purity, and also of distinguishing betwixt the relative qualities of different parcels of ore.

The apparatus required are a good balance and a set of grain weights; a glass bottle, of about an ounce capacity, and a well-ground stopper; and a jug containing water at a temperature of about 60 deg. Fahr.—the other requirements being the bestowal of a due amount of care and attention. The process is conducted as follows:

1. A fair and dry sample of the ore to be tried having been taken, a small quantity (say 200 or 300 grs.) is carefully weighed out of it.

2. The glass bottle having been perfectly filled with water, the stopper replaced, and all adhering mixture wiped off, is also carefully weighed, and its weight added to that of the ore.

3. A portion of the water having been emptied from the bottle, the ore is poured, without waste, into it, and, after having been well shaken to drive off the air-bubbles contained in the ore, the bottle is again filled with water, the stopper replaced, and the whole reweighed together.

4. The weight of the bottle of water and ore in it is subtracted from the combined weights of the ore (No. 1), and bottle of water (No. 2), the difference showing the bulk of water displaced by the ore.

Lastly.—If the weight of ore is divided by the difference or loss, the quotient will represent the specific gravity of the sample tried.

For example:

	Grs.
A sample of dressed Cardiganshire silver-lead ore (galena) weighs	200.0
The bottle full of water weighs	644.4
Combined weight of bottle of water and ore	844.4
Weight of bottle of water containing also the 200 grs. of ore	816 7
Difference or loss	27.7

Then, $200 \div 27.7 = 7.22$, the specific gravity of the ore tried.

I have appended to this paper a list of the most frequently occurring ores, and the specific gravity of each description when naturally and chemically pure. By referring to this table, it will be found that the density or specific gravity of pure galena (sulphide of lead) is 7.5 therefore as we have in our sample only succeeded in obtaining a density of 7.22, we not only know that the ore is not perfectly clean, but we also know approximately, and by a simple and expeditious process, to what extent the sample stops short of the highest degree of purity attainable by washing processes. So practically serviceable is the method, that in the supervision of the mines under my control I am constantly in the habit of using it as a ready means of distinguishing between the well and badly dressed samples, and the relative qualities of the various ores prepared for sale. As the density of a pure ore or mineral remains constant under all circumstances, it follows that when the specific gravity of a body is known the miner can, if he has any doubt as to the identity of any particular ore, form a

pretty correct conclusion as to what a substance is, or is not, by means of its specific gravity alone. For instance, supposing it to be difficult to distinguish by the eye betwixt the small crystals of tin and those of blende, an appeal to the specific gravity of each would alone be sufficient to settle the question, the density of tin ore being 6.5, whilst zinc-blende is only 4.0 times that of water.

The following table gives the specific gravities of some of the most important of metallic ores.

Name of substance.	Spec. grav.
Antimony—Native	6.6
Oxide	5.56
Sulphide	4.6
Arsenical	6 2
Antimonial—Nickel	7.5
Arsenic—Native	5.7
Yellow sulphide	3.48
Red ditto	3.5
Arsenical—Pyrites	7 0
Iron (mispickel)	6.0
Barytes—Carbonate	4.29
Sulphate	4.3–4 6
Bismuth—Native	9.7
Blende	5.9
Carbonate	6.9
Sulphide	6.4
Cadmium—Sulphide	4.8
Cobalt—Arsenical	6.4
Black oxide	2.2
Bloom	3.0
Pyrites	6 3
Cobaltine	6.1
Copper—Native	8 5
Blue carbonate	3.5–3.8
Green carbonate	3.7
Chloride	4.4
Gray	4.7
Phosphate	4.2
Pyrites	4.1
Red oxide	5 9
Silicate	2.0–2.3
Vitreous sulphide	5.5
Gold—Native	14.–19.
Iron—Brown ore	3.9
Carbonate	3.0–3.8
Chrome	4 3
Magnetic	5.0
Pyrites	4.8–5.1
Red hematite	4.8–5 3
Lime—Carbonate	2.5–2.8
Tungstate	6.0
Lead—Native	11.3
Arseniate	7.18
Carbonate	6.46
Chromate	6.0
Molybdate	6.3–6 9
Oxide (minimum)	4.6
Phosphate	6.9
Sulphide (galena)	7.5–7.7
Sulphate	6.3
Tungstate	7 9
Manganese (wad)	2.5–3.7
Oxide	4 8
Spar	3.4–3.7
Mercury—Native	13 6
Chloride	6.4
Sulphide (cinnabar)	8.0
Molybdenum—Sulphide	4 5
Nickel—White arsenical	6.4–6 7
Glance	6.1
Pyrites	5.2
Palladium—Native	10.–12.
Platinum—Native	17.–19.
Silver—Native	10.–11.
Antimonial	9.4–9.8
Chloride (horn)	5.55
Glance (sulphide)	7.19
Ruby	5.7–5 9
Telluric	8.3–8 8
Strontia—Carbonate	3 6
Sulphate	3.9
Tellurium—Native	6.1
Tin—Oxide	6.5–7 0
Pyrites (sulphide)	4.3
Titanium—Oxide	4.2
Wolfram—Tungstate iron	7.0
Zinc—Blende (sulphide)	4.0
Carbonate (calamine)	4.3
Oxide	5.4
Silicate	3.4

In my next letter it is my intention to point out other useful and interesting facts upon the subject of "The Metals and their Ores."

A Travellers' Theodolite.—L. Casella, of London, is manufacturing a small transit theodolite, which is contained in a box 4 by 5 by $6\frac{3}{4}$ inches, outside measurement. It has a telescope, complete 3 inch horizontal and vertical circles with verniers reading to 1 minute, and can be used not only as a theodolite for terrestrial surveying, but also as an altazimuth for determining time, latitude, and azimuth astronomically. Its diagonal eye-piece admits of the observation of zenith stars easily. It has a reflector for illuminating the wires at night, a dark glass for solar observations, a finely divided level, a compass and apparatus for all the necessary adjustments. Such an instrument may be very useful to scientific explorers and engineers making preliminary reconnoissances in a new country.

The glass works of J. B. Ford & Co., New Albany, Ind., cover an area of 7 acres. They give employment to 200 hands, and turn out over 1, 600 boxes of glass per week. Among their products is rough plate glass for sky lights, floors, etc.

IMPROVEMENTS IN RAILWAY CONSTRUCTION.

From "The Mechanics' Magazine."

One of the greatest branches of civil engineering—we use the adjective in its literal not in its technical sense—possesses an aspect in the present day which is the very antithesis of some departments of modern construction for purposes of warfare. While, on the one hand, we see each year larger iron-clads laid down on the stocks, and bigger cannon constructed with which to arm them, a remarkable change is coming over the dreams of the older railway engineers, and if ever a technical question was promised searching investigation in all its bearings surely the question is railway engineering. While one class of engineers are emulating each other in building or proposing big guns or big armor-plates, many of their brethren, whose labors are to promote commerce instead of improving munitions of war, are devising every conceivable scheme to diminish the cost of railway construction.

When the railway principle was first embodied in anything like a national line we got the Great Western with a gauge of 7 ft.; even at that early period, however, in the system a powerful opposition was made to the adoption of an arrangement that demanded so large an outlay. Since then every effort has been made to render the principle of traction on rails subservient to the needs of commerce in less expensive fashion than even the cheapest existing railway exemplifies. The cost of the mere rails themselves, although an important feature in the maintenance bills, is one quite apart from those heavier outlays represented in huge earthworks and colossal bridges. So energetic are these efforts that nearly every conceivable gauge is proposed, from the existing and popular 4 ft. 8½ in. down to what we must, at the risk of being accused of perpetrating a bull, designate as no gauge at all, and represented in a patent lately secured in which a single rail is intended to be employed.

Commerce, to benefit all its votaries in a like degree, must have uniform facilities for its operations. It is to no purpose that one man has as valuable goods to sell as another, unless he can bring them to market as quickly, in as good condition, and at as small an outlay. Perhaps the most valuable commodity since the advent of railways is time. Never was there a period when the "first come first served" maxim obtained so completely as the present; this question of time affects all alike, because the most rapid commands all other transactions. The necessities of this principle apply to colonies as well as to old countries, to outlying provinces as well as to leading centres of commerce, and until colonies are supplied with the same, or nearly the same, means of intercommunication, they cannot deal on equal terms with such countries as already possess them.

When the railroad question is considered in its bearings as provided for the purposes of new countries it contrasts favorably even with common roads. This may at first seem a startling assertion; nevertheless it is a true one. A road, in the generic sense of the expression, is simply a device by which a load is sustained and which admits of that load being moved over it with a certain tractive force.

Examining the power to sustain we find it is simply a question of area. If a wheeled carriage with tyres (say) one inch and a half wide is placed in soft mud it at once sinks till a firmer bed is reached; if it be set on planks laid over the surface of the mud, then it rests secure because of the larger area. This appears trite, but nothing is so trite as an established principle, yet without principles engineering would perish. Now a rail is simply a girder, neither more nor less; if, then, we can lay along the ground a succession of girders properly provided with base area proportionate to the nature of that ground and the magnitude of the load to be borne, we have the railway principle at once embodied. The common road is another affair; in it we merely labor to thicken or stiffen the mud to such consistency that it may be able to prevent the wheels sinking therein; but in moving the carriage over this road there is no provision to secure the progress of the wheels in a straight or a uniform direction; therefore the road must have large margins for lateral deviation.

The leading reason why the railway principle develops so slowly at present in new countries, and even in thinly populated districts in old ones, is that it is so persistently regarded as the exponent of the most advanced civilization, and, consequently, we fall into the habit, when thinking or discussing questions of railway construction, of picturing to our imagination palatial stations, 40-ton engines, saloon carriages, and a speed of 50 miles an hour. Happily, we are beginning to break through this narrow view of a great principle, and are learning to take a more extended one. Many a clever engineer would be startled if told that in certain places, and those the least of all adapted for a railway according to human wisdom, are the places in which Nature has herself provided such facilities that a few men with hatchets can in 3 or 4 weeks construct a length, to be measured in miles, of a road to all intents an excellent railroad capable of conveying goods, and, if a little additional care be exercised, passengers also with speed and safety. An example of such a line is to be found in Italy, where the wood lumberers, as the Americans would call them, lay down trunks of trees side by side longitudinally in the direction of the road ; if on the ground, well and good; if a precipice intervene, then shallow steps are cut in the face of the cliff and transverse bars are laid projecting out like brackets and sustained at the outer extremities by thrust members, roughly recessed into the horizontal cross timber at one end and into the face of the rock at the other. Then on these the trunks of trees are laid longitudinally, as on the ground, and so arranged that the small ones are at the centre and the others increase in size to the sides of the road. This is simple enough, but something is still wanting to complete the line. The next process is to throw water on this timber roadway, which speedily freezes; then more and yet more water till a stout veneer of ice is formed, and which, from the large trees being outside, is in hollow or depressed in the centre of the cross section of the line. Where there is a curve an additional stick is placed as a guard rail outside and resting on top of the outer stick. Here, then, the Italian lumberers have provided a regular tramway, down which they send their timber balks, the speed being sometimes as much as 20 miles per hour, the line throughout being on a considerable inclination from the woods at the base of the Alps down to the valleys below. The timbers being started at the one end, slide like a ship when launched from the stocks right away to the other end. From this we perceive that it is possible to embody a principle without elaborating a mass of scientific matter, which, however valuable in other circumstances, is inapplicable to railway-making in the Bush.

As one example of how our habitual method of regarding the railway question cramps its application in a rough way, is the question of gauge. To this day, whenever a novelty in railroad construction, apart from mere questions of permanent way, is under discussion, the word gauge is as sure to turn up as King Charles's head did in Mr. Dick's memorial. Even the roughest tramway is laid to a gauge, very properly of course, where the doing so does not involve any particular point of trouble; but did any enterprising individual ever yet think of whether a line might be made without the presence of a skilled supervision to see that the rails were of a perfectly uniform distance apart? This necessity for care in laying the rails is one obstacle, or is made one, to the construction of rough railways. Another perhaps as serious grows from it, and is found in the necessity for, in some sort, special vehicles. Now there is no reason why this last evil may not be greatly diminished, and we would suggest the principle of making one of each pair of wheels to run loose on the axle and to have liberty of movement on it in the direction of its length ; of course the wheels would need double flanges, but it is as easy to have two as one. With vehicles of this nature a line with light rails could be laid down in places where timber was at all plenteous with great dispatch, and at less cost than a macadamized road could be constructed, while at the same time furnishing the germ of what as the country progressed could be gradually elaborated into a first-class railway. Doubtless, the loads on such a line should be light, therefore they could but at first be the means for any wheeled carriage drawn by a horse to pass over, and be improved afterwards.

Grading of the Utica, Clinton, and Binghamton Railroad is completed.

NAVAL GUN CARRIAGES.

From "The Engineer."

A little problem for mechanical engineers :—Given one of the Peninsular and Oriental Company's steamers, say 3,000 tons burthen, also a heavy sea, also a tank locomotive, weight 35 tons, mounted on the upper deck of said Peninsular and Oriental Company's steamer ; locomotive to stand across the deck, with the smoke box toward the bulwark ; required :—means for running said tank locomotive in and out through a distance of 6 ft., also means for training the after end of said engine through an arc of 80 deg. without going half an inch in advance of, or stopping half an inch behind, a given point ; also means for lifting said tank engine bodily through a height of about 2 ft. ; also means for lifting first the rear, and afterwards the front end of said tank engine, so that a line passing through the centre of the boiler can be ranged through 16 or 18 deg. of arc—all to be done, be it remembered, in a heavy sea, the ship pitching and rolling the while. We believe we shall not wrong the members of our profession if we state that there is not a man among them who would not shrink from solving the problem, if any could be found who would, just at the first sight of the thing, admit that it could be solved at all. But there is no doubt whatever that the problem can be solved. The working of a 35-ton gun, weighing with its carriage and slide at least 42 tons, can be managed on board ship, and it is not less difficult to manœuvre a 35-ton gun than it is to manœuvre a 35-ton locomotive. In point of fact it is more difficult, inasmuch as the gun has to stand charges of 120 lbs. powder, and a shot weighing over 6 cwt.—three shots to the ton! and the enormous recoil due to the firing of this charge has to be taken up and disposed of within a moderate distance, say 6 ft. or 7 ft., and the powder has to be put into the gun, and the shot lifted some 5 ft., and put in after the powder, and the gun has to be raised or depressed, and trained round ; and all this must be done on a platform in violent motion, and at such a speed that two shots at least can be fired in every three minutes. This is the work the designers of modern naval gun carriages have to perform. The fact that they have performed it constitutes one of the most magnificent triumphs of mechanical engineering yet seen, if we take into account the limited space and limited power available.

The problem has not been solved by trained mechanical engineers ; on the contrary, as far as the British navy is concerned, it has been solved by a naval officer—Captain R. F. Scott. It is not to be supposed that mechanical engineers possessing a thorough knowledge of all the conditions to be fulfilled are unable to contrive means of working a heavy gun, in a sea way ; but, as a matter of fact, mechanical engineers do not, from want of opportunity or other causes, possess the requisite knowledge ; and as a result, the problem has been solved, we think we may say satisfactorily, by an officer who combines a rare knowledge of mechanical proprieties with a keen appreciation of what is and what is not wanted on board a ship. Certain it is that there is hardly a heavy gun in the navy which is not mounted, or about to be mounted, on a carriage embodying some one or more of Captain Scott's inventions ; while there is not a single gun in a British turret ship which is not mounted on a carriage designed throughout by Captain Scott.

We have referred in another place to the process of welding together the principal coils of the 35-ton gun now being made at Woolwich, a gun which, all going well, as we have reason to believe will be the case, will be the most powerful piece of ordnance the world has ever seen. In the carriage department of the Arsenal may be seen, in course of construction the carriages intended to carry this and three similar guns on board the Sultan. It would be very difficult to make the construction of these carriages clear without the drawings, which we hope to be able one of those days to place before our readers. It must suffice to state the nature of the work to be done, and of the means employed in doing it. First, the gun must possess the power of being raised and depressed through varying angles. Secondly it must possess the power of being run in to be loaded, out to be fired. Thirdly, it must possess the power of being turned right

and left through a large arc. If it is mounted in a turret this work is done by rotating the turret, but it is not indispensable that heavy guns should be mounted in turrets. There are plenty of 18-ton guns working on the broadside system, and there is no doubt but that a gun twice the weight could be so worked if it were found expedient. Fourthly, means must be provided for taking up the violent recoil due to the explosion of great charges of powder. Fifthly, means must be provided for lifting the whole gun bodily through a considerable height. We shall consider these five problems and their solution *seriatim*.

First, then, as to means of raising and depressing the gun through different angles. The weapon is mounted on trunnions and has a certain preponderance at the breech end, by which it is supposed to be always kept on a heavy screw supporting the preponderance. It may appear a very simple matter to design a screw which will deal with this moderate load in a perfectly satisfactory way; but in practice it is not found easy. Between the rolling of the ship and the violence of the jerk due to recoil, these elevating screws have always been troublesome affairs to deal with. They either go so stiff that great power is required to run them up, or they go so easily that the instant a charge is ignited they run down, and the gun must be depressed again before a shot can be fired with a chance of hitting the mark. This difficulty has been overcome, we shall not now stop to say how. It would be waste of space without drawings, which, as we have already stated, we hope ere long to be able to place before our readers. Next as to the means of running in and out. The gun is mounted on a carriage consisting of cast-iron distance pieces fixed between two heavy wrought-iron cheeks. This carriage rests on the "slide," an oblong frame of iron which is anchored, so to speak, by a Y piece to a strong pivot placed as close as possible to the porthole. This pivot acts as a centre, round which the slide traverses on small brass conical wheels or rollers running on "racers"—that is to say, a curved permanent way let into the deck. The slide is composed of a pair of very heavy wrought iron I girders, the spaces between the upper and lower flanges of which are filled in with teak. The gun carriage proper slides on the upper surface of these girders when recoiling, but when the gun has to be run out a lever is brought into play, which, acting on an eccentric, throws down rollers which take the weight of gun and carriage and permit both to be run out with great ease. As soon as the gun is out the eccentric lever is released, and the gun carriage then slides or skids on the upper edges of the two sides of the "slide." The gun comes in by the force of its recoil. It is carried out by turning a winch handle, which actuates an endless chain of flat links—just like a gigantic watch chain—kept taut by an ingenious arrangement of india-rubber springs. A clamp beneath the carriage can be caused to seize this chain at any time. The clamp is of course released when the gun is to be fired. The friction between the slide and the carriage is very great, but it is not alone sufficient to control the recoil. This is effected by the aid of two "bow compressers," one being sufficient for all ordinary purposes, and the other being used only in emergency. We could not make the details of this compresser clear without drawings. It will suffice to say that it resembles a boilermaker's horse-shoe cramp on a large scale, and that being fixed to the carriage it compresses the teak beams, let in on either side of the slide beams, between two flat plates of iron, by which so much friction is brought to bear that the recoil of the gun is readily controlled. Hitherto gun carriages have been made very high and the slides very low; the result is that no free access can be had to the slides or space beneath them, and that in washing decks, the water lies between the slides, and under the gun, rusting and rotting the machinery. In the second place the centre of impulse of the recoil being far above the centre of resistance of the compresser, the gun tends to kick off the slide, tipping up in front, or, in other words, rotating round the centre of compression. Captain Scott gets over both difficulties by reducing the height of the gun carriage, and increasing its length, while he raises the slide to make up for the space lost. The centre of impulse and resistance are thus approximated, and the tendency to tip is got rid of. Fourthly, we have to consider the means by which the slide is caused to wheel round through the requisite arc. This is effected by means of two wrought iron pinions,

gearing into a large bevel wheel at the rear of the carriage, and actuating an inclined shaft, terminating near the middle of the length of the slide. On this end of the shaft is mounted a pinion, which gears into a rack "racer" fixed on the deck; by this means the slide can be traversed right or left with the greatest ease. But it has not only to be traversed, but held in place; this last is effected by means of the most compact and ingenious break gear we ever saw. We do not exaggerate when we state that this brake complete does not weigh 20 lbs., and could easily be put in an ordinary hat; yet it suffices to control an 18-ton gun in a heavy sea. Fifthly, and lastly, we have to deal with the arrangements for lifting the gun bodily. This is rendered necessary in turret ships by the small size of the port; when great depression is wanted the whole mass of the gun must be raised, when great elevation is required the gun must be depressed. It is, in fact, partial muzzle pivoting. The raising and lowering are effected by hydraulic presses, constructed, we believe, by Messrs. Tangye, of Clement street, Birmingham. We reserve detailed description.

Now it is indisputable that all this beautiful mechanism—for it is, thanks to the skill of the Woolwich Carriage Department, thoroughly beautiful as regards workmanship, and, thanks to Captain Scott, not less beautiful in design as regards mechanical fitness for the discharge of its duties—has been introduced, worked out, and perfected by Captain Scott. We do not disparage the claims of other inventors; we only deal now with absolute facts. Captain Scott has designed and superintended the manufacture of the only naval gun carriages found to answer in the British navy. It is not, indeed, too much to say that it is only because Captain Scott has labored we are able to work anything heavier than a 6-ton gun at sea. His work has extended over years. Both Admiralty and War Office are satisfied with the result, and yet he has never received the smallest recognition for his services from the Government. Is this as it should be? We think not. The Government is not slow to reward when it pleases. Major Palliser has received £15,000 for the introduction of chilled projectiles. How is it that an officer who, without drawing invidious comparisons, has done much more than Major Palliser, goes not only without the smallest reward for his services, but (if we are not mistaken) without the repayment of a considerable sum out of pocket. We hope ere long to supply our readers with full details of the gun carriages in our most powerful ships; we trust we may be enabled to state at the same time, that the labors of the designer of these carriages has met with the substantial recognition which he really deserves.

IMPROVED METHOD OF PRODUCING HYDROGEN GAS.

By C. WIDEMANN.

From the "Journal of Applied Chemistry."

It is well-known that carbon, either pure or combined with hydro-carbon, is decomposed at a temperature of orange red heat by steam, and that it produces hydrogen and carbonic acid, mixed with more or less oxide of carbon. It is also known that the hydrogen resulting from the decomposition of carbon by steam cannot, by the means at present employed, be produced economically; first, because in the generation of steam, a great quantity of latent heat is absorbed. Second, because the vapor produced at a temperature of 100 deg. Centigrade, requires a considerable quantity of free heat in order to raise it to the temperature at which it will be decomposed, and this heat must either be taken from a special apparatus for superheating, or it must be furnished by the incandescent coal which it ought to decompose. Third, because the retorts containing the carbon which decomposes the water, when brought to a red heat, and exposed directly to the steam, soon becomes damaged and unfit for use. This being the case, MM. Tessie du Motay and Marechal, who have lately discovered a mode of obtaining cheap oxygen for illuminating and medical purposes from the manganates of soda, have sought a more practical and economical method of producing hydrogen by the decomposition of

water by means of carbon, and they have discovered the following method, which has given the most extraordinary results :

Alkaline, and earthy alkaline hydrates, such as the hydrate of potash, soda, strontian, baryta, chalk, etc., mixed with charcoal, coke, anthracite, pit coal, peat, etc., and heated to a red heat, are decomposed into carbonic acid and hydrogen, without further loss of heat than that due to the production of the carbonic acid and hydrogen.

The hydrates of potash, soda, etc., and more especially the hydrates of chalk or lime decomposed by the coal into hydrogen and carbonic acid, can be used indefinitely in this process, provided that they are moistened each time with water so as to reproduce the decomposed hydrates.

In this operation, the hydrogen gas is generated without any special production of steam, and may thus be produced without any other generating apparatus than the retorts themselves. These retorts not being exposed to the direct action of the steam, are not subject to any interior alteration or damage.

It follows, therefore, that the hydrogen gas produced by the decomposition of the above-named hydrates by means of carbon, can be generated at a very small cost, and with the same facility as carburetted hydrogens from the distillation of pit coal or other organic hydro-carbon matter.

These alkaline and earthy alkaline hydrates may be mixed with the different mineral or vegetable combustibles, either in a definite chemical proportion or without a fixed or determinate proportion, and in any suitable distillery or heating apparatus, in order to produce, when heated to a red heat, hydrogen gas for illuminating and heating purposes.

The advantage of the production of hydrogen as cheaply as oxygen has been obtained would create a revolution in many industries, and especially in metallurgy.

A cheap method of producing a great heat in order to reduce metals, such as platina, gold, silver, and iron, has been long sought for in Europe, where the oxhydric blow-pipe is now used to melt the platina in a calcium crucible. By this discovery it becomes possible to obtain an immense heat which could be regulated by a simple tap. Enamellers and porcelain makers would thus get rid of one of their greatest troubles. Let us hope that, as MM. Tessie and Marechal have fulfilled their promises in regard to oxygen, they will again be successful in their new discovery, and we assuret hem of our sympathy and interest in this matter.

INDIAN RAILWAYS.

From "Engineering."

It is now just twenty years ago since the first sod of an Indian railway was turned. At that time it was decided to confine operations to two small experimental lines, 150 miles in length, one of 120 miles in Bengal, the other of 30 miles in Bombay. In four years these were opened, but before that time arrived, Lord Dalhousie, then Governor-General, had proposed, and the home authorities had approved of the system of railways which is now approaching completion. At first, only three companies were employed to carry out works in each Presidency, but, subsequently, other lines were grafted upon the original system, and additional companies were formed. Thus, there are now nine companies engaged in constructing and working railways in India. The first section of line in India was 21½ miles, belonging to the Great Indian Peninsula Railway Company, which was opened in 1853. In the following year the East Indian Railway Company opened 37½ miles of their line, and in 1856 the first portion of the Madras Railway, 65¼ miles in length, was completed. By 1860, ten years after the commencement of railway operations in India, 836¼ miles were in working order ; in 1865 there were 3,368¾ miles opened, and at the present time the extent of completed railways in India is 4,628¼ miles in length. By far the greater portion of this consists of a single line only, the portion laid with double lines amounting only to 479 miles, of which 203 miles is on the main line of the East Indian, 256 on the Great Indian Peninsula, and 20 miles on the Bombay, Baroda, and Central Indian Railway. The most im-

portant event which has marked the history of Indian railways during the past year is the junction of the Great Indian Peninsula and the East Indian Railways at Jubbulpore, whereby the whole breadth of the Peninsula is spanned at its widest part, and Bombay and Calcutta, as well as Bombay, Delhi, and Lahore, are brought into railway communication with each other. The East Indian Railway has been opened to Jubbulpore since 1867, but unforeseen delay occurred in the completion of the works of the Great Indian Peninsula Railway, and the long desired junction of the two lines has been deferred in consequence. The works have lately been pushed on with great vigor and rapidity, and although there is still much to be done before the line can be considered thoroughly completed, it was sufficiently advanced to admit of the ceremony of opening being performed by the Duke of Edinburgh and the Viceroy on the 7th of March last. The occasion gave rise to proceedings of much interest in which the Governor of Bombay, the Chief Commissioner of the Central Provinces, Sir Sala Jung, the Minister of his Highness the Nizam, Maharajah Halkar, Maharajah of Rewah, the Rajah of Mijhere, and other functionaries took part. The line in question proceeds from Bombay up the Thull Ghaut *via* Jubbulpore to Allahabad, thence it follows the valley of the Ganges to Calcutta. Before the end of the present year a more direct route will be opened for the latter part of the line by the completion of the chord line of the East Indian Railway to Luckeserai, *via* Raneegunge, to Calcutta. The distance from Bombay to Calcutta by the present route is 1,470 miles. It will then be 1,400 miles.

The year 1869 saw the addition of 261 miles of railway to the already existing lines in India. At the close of 1868 there existed 4,017 miles of open railways, which was increased to 4,278 by the end of 1869. The addition during the year consisted of 30 miles on the northwest branch of the Madras line, and of 231 miles on the Delhi Railway. Since the end of the year a short branch of 8 miles, which has been constructed by Government, extending from Jhellum on the Great Indian Peninsula Railway to the cotton mart of Khamgaon, and 25 miles more of the Delhi line, have been opened, besides $69\frac{3}{4}$ miles between Sholapoor and Goolburga on the south-east branch of the Great Indian Peninsula Railway, and the Jubbulpore line before mentioned. The short extension of the Baroda Railway across the Saburmuttee river, and 2 miles beyond, was also opened on the 1st January last. The whole length of railway now open in India is 4,628 miles. The length of line at present sanctioned for construction in India comprises 6,249 miles, of which 6,005 miles belong to guaranteed companies; $216\frac{1}{2}$ miles are State lines; and the Nulhattee, a subsidized line, is $27\frac{1}{2}$ miles in length. There remain consequently $1,519\frac{1}{2}$ miles yet to be finished. Of these several are on the eve of completion. The chord line of the East Indian will be finished in the course of this year. The line between Madras and Bombay, with the exception of the bridge over the Kistna, should also be opened next cold season. The Delhi line will probably be completed. The Oude and Rohilkund Company will open their first section beyond Lucknow, and the extension of the Eastern Bengal Railway to Golundo will, it is expected, be ready for opening in the course of the current year. Progress has also been made with the Punjab State line, which, with the exception of a few divisions, is to occupy one-half of the trunk road. The lines which form the system of railways for Oude and Rohilkund have now all been sanctioned and staked out, and the earthworks have been formed over many miles. The bridges also have been put in hand, and permanent way material taken to different parts of the line. The Bombay, Baroda, and Central India, and the Great Southern Railway Companies have made every preparation for carrying out with vigor the extensions committed to them ; and the Carnatic Company, which has taken the place of the former Indian Tramway Company, is making the surveys for the extension of the line to Cuddalore, and is about to convert the narrow gauge line between Arconum and Conjeveram into a first-class railway with the standard gauge of 5 ft. 6 in.

With regard to lines in the hands of Government, and which are termed "State Railways," one—the Calcutta and Canning Town—was surrendered by the company which constructed it to the Government ; another—the Jhellum and Khamgaon—was executed under the directions

of Government officers in the space of nine months, and is being worked by the Great Indian Peninsula RailwayCompany; the third, viz., the Lahore and Peshawur line, is being laid out and constructed under the superintendence of Mr. Lee Smith. The lines which are now being surveyed by the Government in view to their early commencement are 1st, from Delhi, in a southerly direction, to Rewaree, with a branch to Furrucknuggur, where valuable brine springs exist; 2nd, from Agra to Sambhur salt lake, and on to Ajmere, forming a junction at some point to be determined on with the abovementioned line from Delhi; 3rd, from Mooltan, by the valley of the Indus, to Rohree; 4th, from Koolburga to Hyderabad; 5th, from Karwar to Hoohlee. No estimates have yet been made of the cost of the lines to be undertaken by Government, nor has it been considered necessary to make any special provision for the raising and issuing of money for the purpose. The line between Goolburga and Hyderabad, above mentioned, is in one sense a State line, although not paid for by the Government. The gratifying announcement has lately been made by the Government of India that Sir Salar Jung, the chief minister of H. H. the Nizam, has engaged to provide a million of capital for the construction of this line, which is to be executed and managed by the Indian Government for the Nizam. The Government have at the same time communicated the fact that H. H. the Maharajah Holkar has also arranged to advance a million sterling for the branch to Indore from the Great Indian Peninsula Railway, the British Government allowing him 4½ per cent. interest upon the loan, and dividing with him ratably, on the share of the outlay contributed by him, the profits over and above that rate.

The 4,628 miles of railway which are now open in India, have cost about £79,000,000. The total amount expended up to 31st March last amounted to £83,444,147, but this includes the cost not only of the open portion, but also of many miles still in course of construction. The gross receipts last year were £5,709,382 as compared with £5,320,723 in the previous year, and the net receipts were £2,520,952, and £2,522,622 in the two years respectively. The railways were thus earning last year at the rate of about £3 4s. 6d. per cent. per annum on the capital expended on them, £1,380,000 short of the guaranteed interest payable on such expenditure, and £1,412,919 less than the amount paid for guaranteed interest on the whole capital raised, including that employed on unopened lines and the unexpended portion as well. The number of passengers carried during the year was 16,011,633, compared with 15,066,530 in the previous year. The amount of goods traffic was 2,588,513 tons. The train mileage was 12,318,086 last year, and 11,980,319 the the year before.

ON CERTAIN PROPOSED IMPROVEMENTS IN THE MANUFACTURE OF HYDRO-CARBON OILS.

From "The Mining Journal."

Mr. David Cowan read the next paper on the subject stated above. He said:—The importance to which the manufacture of mineral oils has attained during the past few years is such as to give it a place among our leading local industries. The oil-yielding materials—that is, the bituminous shales and the cannel coals—are plentifully distributed throughout the whole of the Scottish coal measures, but differ very much in character, both as regards the quantity and the quality of produce. To obtain oils from these materials, they are, first, subjected to a process of destructive distillation, which forms the oils, during which they escape in the form of vapor, while the fixed carbon remains with the ash in the distilling vessel or retort. The economy and efficiency of this operation depend greatly upon the kind of retort, the system of heating adopted, the degree of heat applied, and the efficiency of the condensing part of the apparatus. Various forms and arrangements of retorts have been tried from time to time with more or less success, but full descriptions of all the retorts and ovens that have been tried is not contemplated in this paper. The retorts used in this district belong to either one or other of two types

—the horizontal and the vertical. The horizontal retort is usually rectangular or elliptical in cross section, and varies from 30 to 60 in. in width, and from 8 to 10 ft. in length. They are built in brick-work, and are heated, charged, and emptied much in the same way as the retorts used in the manufacture of coal gas—only a much lower degree of heat is applied. The vertical retort usually consists of an upright cylinder, fitted at the top with a hopper and bell-cone charging apparatus similar to that used on a close-topped blast-furnace. The lower end dips into a trough of water, which, while it admits of the exhausted materials being withdrawn there, prevents the escape of the hydro-carbon vapor, and also the entrance of air into the retort. It is proposed in this paper, first to consider the advantages and disadvantages of each of these classes of retorts, and afterwards to describe an arrangement of apparatus designed to combine the advantages of both, and which at the same time will admit of improved facilities for working. In horizontal retorts the depth of the charge of material is very much less than in vertical retorts, and the passage of the oil vapor through the material to the surface is, therefore, comparatively easy. The outlet pipes are generally at the end of the retort furthest from the furnace, and would be upon a level with the upper part of the material of the charge, and the unobstructed vapor escapes freely, which is greatly conducive to a good yield as well as to a good quality of oil. The vertical retort is generally about 10 ft. in height, and is completely filled with shale up to the mouth of the discharge pipe. The passage of the vapor from the lower portion of the retort is considerably obstructed by having to pass through such a depth of material, and there is much loss by condensation in the upper part of the retort before the vapors reach the exit pipe, and in consequence of the condensation the vapor falls down into a hot part of the retort, and is again exposed to a temperature equal to that at which it was formed, and partly decomposed, and is deprived of a portion of its hydrogen. There is thus caused a deterioration of the quality and a diminution of the quantity of light or burning oil. Altogether the oils from these vertical retorts are of inferior quality, as compared with the produce of horizontal retorts, while the quantity of uncondensable or permanent gas is increased. The work of charging and discharging these retorts is, however, considerably less. The arrangement herein to be proposed and described belongs to the vertical class, with improvements calculated to remedy the evils we have been describing as attaching to them. The writer went on to illustrate by a series of diagrams the operation of the retort, which was charged from the top, the bituminous materials in small pieces being put into the annular spaces between the grating and the inside. When heated to a proper temperature—say, between 700 deg. and 800 deg. Fahr. —hydro-carbon vapors are formed and given off. These find their way into the grating pipe—the coolest part of the retort—and when assisted by the exhausting fan will speedily find their way through the eduction pipes into the condensers. Thus the thickness of shale through which any of the vapors must pass before reaching the outlet pipe is only the width of the annular space—say, 8 in. In this form of retort the vapor does not require to ascend at all, and although it may partially condense within, it cannot return to the hottest part, but must pass downwards towards the condensers, and, therefore, whatever loss is due to the decomposition which is usual from this cause will in a great measure be saved. It appears to the writer that another important improvement may be effected in the way of heating or firing the retorts. In heating them by ordinary coal-burning furnaces, constant, regular, and watchful attention to the condition of the fires is required. The regular maintenance of the proper temperature may be said to embrace the whole of the skill required for distilling crude hydro-carbon oils. It has occurred to the writer that, instead of firing with coal, the retorts should be heated with gas flame, as, besides economizing fuel and labor, it will meet the requirements of regularity and watchfulness more satisfactorily than the present system, as when once the gas is lighted and the flame adjusted, further attention will be unnecessary. It is here suggested that the system of first converting the fuel into gas (so successfully worked out by Siemens) should be adopted, and the drawings show generally how such a system can be applied. They also show the arrangement of

the flues and indicate the direction of the currents. Inspection will show that the air necessary for supporting combustion will be heated previous to entering their furnace. This mode of heating by gas instead of by solid fuel, and with hot air supplied to the furnaces, should, besides the more important advantage of regular temperature, effect a saving of from 40 to 50 per cent. of fuel. The author has also directed his attention towards economizing the labor required for charging and discharging these retorts, and with this object in view he has designed an arrangement of machinery for serving the materials to the retorts, as shown in the drawings. In describing the action of the machinery, the steam-engine used for working the pump and fan would communicate motion to the end pulley or wheel. The motion should be adjusted so that the chain will be moved over the pulleys at a speed of about three miles an hour. The empty buckets as they reach the loading bench, on a level with the surface, are filled with material, and are afterwards carried by the moving chain upwards and along above the top of the retorts ; and at whatever bench it is desired to empty these buckets a pin is to be inserted into the eye-hole formed in the arms V V, which engages the arms U U on the bucket, and tilts it in the manner shown on the drawing. When emptied, these buckets immediately right themselves, pass onwards and round the far end wheels, and return to the top line of chain, to be again filled at the loading bench. The mineral, when deposited on the top of the benches, can be conveniently raked into the mouths of the retorts, or may be so arranged as to empty direct into the retorts. The same apparatus will convey the coal drop to the gas generators. This machinery might be simplified by using only one endless chain, or by adopting a modification of the wire tramways ; but the arrangement here proposed is preferred where large quantities of materials require to be operated upon. The drawings show a tramway laid along the front of the retorts, which is provided with turn-tables for running small wagons into openings, W W, which are formed in the backwork underneath them. The potters which secure the bottom covers are withdrawn, by a portable screw apparatus, worked from the outside. The bottom then falls down and the exhausted shale empties out of the retorts into the wagons underneath, by which it is conveyed to the refuse heap. Thus the work of charging and discharging is reduced to a minimum. The arrangement for discharging the retorts is as follows : Each pair of retorts are connected at the bottom by a horizontal tube, on which are cast two brass sockets or faucets, for receiving the bottom ends of the retorts. The ends are closed by covers, one of which is a fixture, and is provided in the centre with a stuffing-box. The other centre can be removed at pleasure. A shaft is fixed along the axial line of this horizontal cylinder, on which are fixed two screen blades, one under each retort. These are revolved by suitable gearing, and will discharge the spent materials into a small wagon, resting on the tramway in front of the benches. This would be a more expensive arrangement, but the advantage which it has over that previously noticed is that the shale is discharged in front instead of underneath, and that the workmen will not be so much exposed to the noxious gas which is discharged from the used-up materials. A simple defective stop-valve for fitting on to the eduction pipes is also much wanted in mineral oil works. The majority of such valves in use are either plug-valves or hydraulic cup-valves, worked by a rod passing through a packing box in the valve-chest cover. Plugs are seldom tight, and generally there is also a leakage from packing boxes. Cup-valves are always tight in themselves, but still they are liable to leak at the stuffing boxes. The condensers are riveted sheet-iron tubes, about 15 ft. long and 2 ft. in diameter, placed upright in a wall of brick-work, and have a central tube running throughout their entire length. The annular space between the outside and inside tubes should not exceed 3 in. in width. The joints which connect the gas and oil exit pipes are all secured by hydraulic seals, and provision is made for maintaining a constant depth of the sealing liquid around them. The oil main is placed underneath the condensers, and rests in a niche formed in the supporting wall. A 2 in. pipe runs along the bottom of this oil main, into which hot water or steam from the engine boiler can be poured at pleasure. This completes the description of the arrangement of plans which

form the subject of this paper. The details have not been minutely gone into, all that was intended being merely a general description of the modifications proposed, and this may be sufficient to induce discussion, and be the means of directing further attention to this object on the part of our Institution.

THE PRACTICAL APPLICATION OF THE CHRONOSCOPE.

From "The Mechanics' Magazine."

In our second notice of the Conversazione of the Institution of Civil Engineers, which appeared in our issue for June 10 last, we described the highly ingenious chronoscope invented by Capt. A. Noble. One of the uses of this apparatus we there stated to be the recording at one observation the velocity with which a projectile passes different points in the bore of a gun. But it has other practical applications, which we also there promised to place before our readers, together with some of its working results. Before proceeding to fulfil that promise it may be as well briefly to revert to the apparatus itself, and to note what has been previously done in this direction. About 130 years since, Robins invented the ballistic pendulum for measuring the velocities of projectiles, and as late as 1854 Colonel Boxer stated in his treatise on artillery that the experimental data afforded by the ballistic pendulum formed the basis of the whole science of artillery. Since then we have had Major Navez's electro-ballistic apparatus, which was improved upon by Colonel Lewes. This instrument, and also that of Major Benton, have been superseded by the chronographs of Professor Bashforth and Captain Schultz. These instruments, however, only measure the velocities after the projectile has left the gun, but by Captain Noble's apparatus we can measure velocities within the bore. Then with regard to the relative pressures on the gun it was thought a great achievement not long since, when these were obtained by screwing pistol barrels into the metal and measuring the velocities of the balls forced from them by the gas. Rodman's pressure gauge for showing the actual pressures, in which a knife is driven into a copper plate, has now given way to a new crusher, of which we shall presently say more.

The chronoscope consists of a set of discs fixed on an axle, and which are set in motion by a heavy weight, their relative velocity being regulated by a train of wheel gearing. Hollow plugs are screwed into the barrel of the gun at intervals, and pass from the outside of the weapon to the interior of the bore. As the projectile passes each plug in succession it presses a cutter which projects from the plug into the bore, and cuts a wire passing through the plug to the outside of the gun. Each of these wires is the primary wire of an induction coil, and its rupture causes a spark to pass between the secondary wires, which are connected each with the revolving discs, the edges of which are covered with white paper coated with lampblack. The spark burns away the lampblack at the point of discharge, and the white spots thus formed indicate the velocity of the projectile between the several plugs in the gun. So far the arrangement for taking velocities and for noting the powder pressure on the projectile. For ascertaining the strain of the powder on each part of the gun a number of steel plugs are screwed into the barrel from breech to muzzle. Each of these plugs contains a small solid copper cylinder, which rests against an anvil fixed in the plug, while a movable piston rests against the end of the copper. These are the crusher gauges, and they act in the following manner: When the charge is fired the gas presses on the piston and crushes the copper cylinder against the anvil. The effect of any given compression can be ascertained by a testing machine, so that the amount of compression sustained by the copper becomes a direct indication of the pressure of the gas. This crusher has been proved to be far more accurate than the Rodman gauge.

With these ingenious arrangements the committee on gunpowder and explosive substances have been enabled to construct time curves and velocity curves showing the motion of a projectile in the bore of the gun with various kinds of powder, and pressure curves showing the strain of

each kind of powder on the various parts of a gun. The rate of motion of the shot in the gun under every change of condition, and the strain on the gun at every point, can now be accurately mapped out on paper—a result never before attained with anything like real exactitude. It is satisfactory to find that these great strides in science are not barren of practical results, but that on the contrary they have proved highly useful and instructive. The committee above referred to have issued a preliminary report from which we learn some interesting particulars. From their experiments the committee have ascertained that in the 8-inch gun, with which their trials were made, a certain kind of powder known as "pebble powder, No. 5," gives, when compared with rifle large grain service powder, some remarkable results. This powder is made by breaking down press cake of a density of 1.80 into lumps of a certain size, which are afterwards finished in the usual way, occasioning but a very slight departure from the ordinary course of manufacture. A charge of 35 lbs. of pebble powder gave 50 ft. more velocity to the projectile on leaving the gun than a charge of 30 lbs. of R L G powder, and yet exerted only about half the strain upon the gun. We cannot overestimate the value of this result, especially as the advantage in velocity was fully maintained when battering charges were fired with the two descriptions of powder from a 10-inch gun under proof with 400 lbs. projectile. There is, in the first place, the great advantage that while maintaining and even increasing the present velocity of our projectiles for battering purposes, the use of the pebble powder will materially reduce the initial strain exerted by the exploding charge, thereby prolonging the life of the gun and diminishing the risk of accident. In the next place, it appears probable that the reduction in violence of explosion effected by the use of such a powder will diminish the liability of projectiles to break up in the gun, and also modify the scoring action of the gas upon the surface of the bore. Finally, there is a probability that another important advantage will be secured, namely, the attainment with safety of a considerable increment in velocity with heavy guns, whereby a material increase will be effected in the power of our armaments.

From the report in question we learn the action going on inside our heavy artillery, and we can trace the effect of the powder, not only upon the projectile at every point of its flight from the breech to the bore, but upon the gun itself at every part until the projectile leaves the bore. Incredible as it may seem, these are only simple matters of fact, and are effected by means of the apparatus we have been describing. All kinds of powder can now be compared, and have been compared to a good purpose as we have seen, and in this the committee have done good service so far as they have gone. In their memorandum of instructions their attention was specially directed to the importance of an early determination of the description of gunpowder, the employment of which in large charges is attended with the least risk of overstraining the guns, and they were desired to report progress from time to time. Up to the date of their report they, therefore, gave their attention specially and almost exclusively to this branch of the inquiry. As we have seen, they have made sufficient progress to prove that there is no difficulty in producing a description of powder much better suited for guns of large calibre than the present service powders. We understand that this pebble powder is being manufactured at Waltham Abbey, and we congratulate the committee upon the success which has attended this branch of their investigations.

The Lewistown, (Pa.) "Gazette" says: Glamorgan Furnace turned out 489 tons of pig metal during the month of June, and is now filling an order of 800 tons for the Cambria Iron Works. Weep, True Democrat, weep—your British nobles have lost a good job, and British pauper laborers a good deal of work, for this iron will be made into American rails! What a terrible nabob Mr. Morrell must be to give all the main products of this work to owners of American ore, American workshops, and American workingmen, when he could buy the articles ready made in England, Wales, or Scotland, cheaper than he can get it made here!

The new agricultural works at New Castle have at present 1,000 new machines in the course of construction.

IRON AND STEEL—A VERY COSTLY AND VEXATIOUS FALLACY.

Contributed to "Nature," by W. MATTIEU WILLIAMS.

I.—"A friend of mine has been converting some common cinder pig-iron into either very fine iron or steel by a very simple process, but does not know who to apply to to learn its value. He is willing to share the profit with any one who will help him in the matter. I have some small samples of it if you would like to see it, or can tell me who would be likely to interest themselves in the matter. From what I can make out I should think it would make good steel, for it will harden and temper now."

The above, quoted from a letter I have recently received, is a typical sample of a number of others I have had at different times, and it represents the labors of quite a multitude of patient, long-suffering, and miserably deluded investigators. The published specifications of abandoned patents make painful record of wasted money, time, and ingenuity; and suggest dark tragedies, of ruined hopes, all arising from the same misunderstanding of the changes which take place in the conversion of *ordinary* pig-iron or cast-iron into *merchantable* steel.

The most humiliating feature of this delusion is that it is not the offspring of popular ignorance, is not prevalent among the beer-drinking class of iron-workers, who sign their names with a +, but crops out among intelligent self-taught men, who have studied the chemistry of iron and steel as expounded in recognized chemical books. The costly fallacy I allude to is directly traceable to the teachings of our highest scientific authorities. As "Nature" is now largely circulating among the class of self-taught and energetic men who supply this ever-recurring crop of victims, and also among those who most unwittingly and unwillingly have deceived them, there can be no better medium through which to effect the demolition of this mischievous error.

By reference to almost any text-book on chemistry, it will be found that cast-iron is described as a compound or mixture of iron and carbon; that steel is another compound or mixture of iron and carbon, but with a less proportion of carbon; and that wrought iron is nearly free from carbon. Further, we are told that the ordinary method of making steel is, first to remove all the carbon from the cast or pig-iron by making it into wrought or bar-iron, and that this bar-iron is afterwards converted into steel by causing it to take up a new dose of carbon in the cementing furnace. The natural inference of a thinking reader is, that this is a clumsy complication, especially if he knows that the process of cementation is slow and costly, that on account of the irregular diffusion of the carbon in the blistered bars, other expensive processes of shearing, tilting, casting, etc., have to follow. Why not at once produce the steel from cast-iron by a process of decarburization which shall stop at the right point, *i. e.*, when the 3 or 4 per cent. of carbon of the cast-iron is reduced to the one or one and a half per cent. required to produce steel? By doing this not only the cost of converting wrought-iron into steel, but also the cost of puddling to produce wrought-iron will be saved; and steel, which is but a carburet of iron intermediate between cast and wrought iron, instead of being so much dearer than either, should be made at an intermediate cost, or cheaper than wrought-iron.

If he dips further into the literature of the subject, and reads the history of the manufacture of iron, he will find further confirmation of such reasoning, as he will learn thereby that the direct production of steel is an ancient art, and that weapons of renowned quality were made from steel thus produced.

By reference to one of the most recent and elaborate English treatises on the subject, Dr. Percy's "Metallurgy," he will find on page 778 that this is described as "the ancient method, which is still extensively practiced on the continent, especially in Styria;" and further down on the same page that "if steel be regarded simply as iron carburized in degrees intermediate between malleable and cast-iron, then it is obvious that the latter during its conversion into the former in the processes of fining and puddling, must pass through the state of steel." On page 805 of the same work he will find further confirmation of his theory in the words, "it is obvious that steel must be produced by

melting malleable and cast-iron together in suitable proportions."

I might multiply quotations from this and every other work I have seen in which the chemistry of iron and steel is treated, and show by each one of them that the thousand-and-one of unfortunate inventors who have struggled in vain to make steel directly from English pig-iron, have been encouraged in their delusion by the teachings of high chemical authorities.

"If steel be regarded simply as iron carburized in degrees intermediate between malleable and cast-iron," these inventors are perfectly justified in seeking some substance which at the melting heat of cast-iron shall give off a definite quantity of oxygen; and they have logical grounds for believing that by bringing such a substance in contact with the molten cast-iron, and properly regulating its quantity, they may burn out just that surplus carbon which makes all the stated difference between cast-iron and steel. As a multitude of compounds when thus heated do give off oxygen, a vast field of effort is open, and accordingly every available peroxide and decomposable oxygen salt has been administered by strange devices to the melted iron, the same obvious substances used over and over again, and the same failures continually repeated by expectant inventors ignorant of what each other have done or are doing. Gas and vapors have been blown over the surface and under the surface, and through from bottom to top of melted cast-iron, and all (including Mr. Bessemer) have failed to produce merchantable steel from ordinary English cast-iron, without first making it into malleable or wrought-iron.

The reason of this is, that the removal of the surplus carbon is only a small portion of the work which has to be done in order to convert cast-iron into steel of any commercial value. Several other substances have to be removed also; *and no process has yet been discovered by which these impurities can be removed without at the same time removing the carbon in corresponding degree.* I put this in italics because I am convinced by experience of its great practical importance; because I do not find it clearly and distinctly enunciated in any general or special treatise; and further, because I have seen so plainly that the want of clearly understanding it is the rock upon which so many unfortunate inventors have split.

These inventors have not been informed with anything like the necessary degree of distinctness, that the Styrians and others who have made or are making steel directly from cast-iron, have started with a very different material to that which bears the same name of cast-iron in England; the difference being sufficiently great to alter totally the conditions of the problem. The cast-iron of the Styrian steel-makers is a nearly pure carburized iron; *our* cast-iron is a carburized, silicized, phosphorized, and sulphurized iron; *their* problem in steel-making is merely the partial decarburization of their cast-iron; *ours* is the total desilicization, the total dephosphorization, and the total desulphurization in addition to this. Now, the partial removal of carbon from iron is one of the very easiest problems in practical metallurgy, while the complete removal of silicon, phosphorus, and sulphur, is among the most difficult.

To illustrate the grossness of the fallacy which represents the difference between cast-iron and steel as merely, or "essentially" due to carbon, I may state that on looking down a tabular statement of the analysis I have recently made of thirty brands of ordinary English pig-iron (excluding hæmatite pigs), I find that seven among them contain less than 2 per cent. of carbon, or an average of 1.77 per cent. Now this is below the percentage of carbon which exists in some of the finest and most expensive samples of cast-steel. Therefore, to convert these particular brands of cast-iron into the finest steel, the carbon must neither be increased nor diminished, and if, as Dr. Percy says, the differences between steel, wrought-iron, and cast-iron, "*essentially* depend upon differences in the proportion of carbon," all these brands of pig-iron should be described as steel rather than cast-iron.

Nevertheless they are utterly worthless for any of the purposes for which steel is used, and the common result of the costly experiments of the inventors who endeavor to make steel directly from English pig-iron, is to produce a material very much like them. They usually succeed perfectly in their effort partially to decarburize the pig iron. They take out, say one-half of

the carbon, and with it a considerable portion of the silicon, and *some* of the phosphorus, sulphur, and manganese ; but to make a *perfect* steel they must take out *all* of these latter, and leave nothing but pure iron and carbon. Absolute perfection is not, of course, practically attainable in steel-making, but it is approximated in exactly the same degree, as the purification of the iron from every thing excepting the carbon is effected.

The most notable modern attempt to produce steel directly by the simple decarburization of English cast-iron was that of Mr. Bessemer. His first idea was to blow air through melted cast-iron, and thereby to oxidize the carbon, and then, when a sufficient degree of decarburization was effected, to stop the blowing. He supposed that when by this means the proportion of carbon was reduced to about one and a half per cent. the result would be useful steel. He failed entirely in this ; he never succeeded in producing merchantable steel from ordinary English cast-iron by this method.

The Bessemer process, as at present conducted, consists in first oxidizing simultaneously all or nearly all the carbon and silicon, and then adding to the decarburized iron a new dose of carbon, by means of a known quantity of spiegeleisen of known composition ; thus reverting to the old Sheffield principle of first bringing the cast iron to the state of wrought or decarburized iron, and then adding carbon to convert it into steel.

It is commonly represented that the failure of the early attempts at direct steel-making by the Bessemer process arose simply from the difficulty of determining the right moment at which to stop the blow, and thereby to regulate the proportion of carbon ; and that the whole advantage of the spiegeleisen is the means it affords of doing this. Dr. Percy says :—"In attempting to produce steel by the methods specified by Bessemer, it has hitherto been found very difficult, if not impracticable, *at least in this country*, to ascertain with certainty when decarburization has proeded to the right extent, and when erefore the blast should be stopped. ccordingly the plan now adopted is to decarburize perfectly, or nearly so, and then add a given proportion of carbon in the state in which it exists in molten spiegeleisen, the precise composition of which should of course be known."* Neither in Dr. Percy's nor any other account of the Bessemer process do I find that the necessity of complete decarburization as a means of completely separating the silicon is fairly appreciated.

If merchantable steel could be made from English pig-iron by simply stopping the blow before complete decarburization, Mr. Bessemer would surely have produced some good steel in the course of his long and costly efforts which preceded the idea of introducing the spiegeleisen, for it must be remembered that the quantity of carbon required in steel extends over a very wide range—that steel may contain from 0.40 to 2.00 per cent. of carbon, and that steel with every degree of carburization within this wide range is in demand in the market at good prices, provided it be free from phosphorus, silicon, etc. Nothing is practically easier than to stop the blow at such a moment as shall insure a degree of carburization somewhere between this wide range ; and there can be no doubt that in his early experiments, Mr. Bessemer, like other inventors of direct processes, made an abundance of iron that was duly carburized within the above-stated limits, although he failed to produce useful steel.

Dr. Percy's qualification, "at least in this country," is rather curious. He has probably learned that steel has been directly made in Sweden (though he does not mention it in his work) by the Bessemer process, and he seems to attribute this to the superior ability of the Swedish operators, enabling them "to ascertain with certainty when decarburization has proceeded to the right extent." I differ entirely from Dr. Percy in this conclusion, being convinced that Mr. George Brown, the manager of the Bessemer Department at the Atlas Works, Sheffield, who was the first to work the Bessemer process with commercial success, is better able (on account of his much greater experience and thorough knowledge of the work) than any of the Swedish manufacturers, to determine when any required degree of decarburization has been attained. It is not the superior skill of the Swedish operators that has enabled them to make steel directly by the Bessemer process ; but the

* "Metallurgy," "Iron and Steel," p. 814. The italics are my own.

fact that they, like the Styrian workers, used a very superior charcoal-iron to start with; and that the blowing out of all the carbon was not absolutely necessary for the sufficient purification of this quality of iron.

II.—The greatest enemy to steel is phosphorus; one-tenth per cent. is sufficient to produce serious deterioration, and even to render the harder varieties of steel utterly worthless. As our common English pig-iron is made from clay ironstones, many of the nodules of which contain, as nuclei or otherwise, the remains of fishes and other animal matter, they are exceptionally rich in phosphorus; and thus all the difficulties of steel-making are greatly increased in this country. There are few results in connection with the progress of British industry of which we have better reason to be proud than our pre-eminence as steel-makers, in spite of the greatest natural disadvantages; and this is the more remarkable from the fact that so great a triumph has been gained by illiterate men who have achieved it by following out with a remarkably sound though unaided sagacity the strict method of true Baconian inductive investigation. Whenever I meet a formulating book-stuffed pedant, I love to tell him of the great unconsidered fact, that, while the learned men of the Middle Ages were muddling their intellects with worthless disputations, the artisans of that period were true inductive philosophers, and that the revival of science only commenced when the men of the universities adopted the method which had always been followed by the men of the workshop.

If the men of the universities have outstripped the men of the workshop in recent times, it is simply due to the fact that science has kept systematic record of its achievements, by means of which each worker has the full benefit of the labors of his predecessors and fellow-workers, and he is able to start from the point where these left off; whereas the workshop observers and experimentalists have worked with little or no systematic co-operation. If such co-operation only among one set of investigators has done so much, what may we not expect when it shall not only be extended to the other, but when both sections shall co-operate with each other? This technical and scientific co-operation is the great want of the present age. The artisan needs scientific education, and the professors of science have much to learn from the great mass of facts included in the practical experience of the workshops.

But I must not at present be carried further away into this tempting digression, but return to my main subject by anticipating an objection which will probably be made. The manufacture of puddled steel may be supposed to refute all I have said respecting the impracticability of producing steel directly from English pig iron. If steel fit for the manufacture of files, chisels, etc., could be made from ordinary English pig iron by this process, all my statements certainly would be refuted, for puddled steel is simply made by checking the oxidation and arresting it at such a point that some of the carbon in the pig iron shall remain unburnt.

The facts connected with the manufacture of puddled steel which bear upon the present subject are as follows:—First, puddled steel of merchantable quality cannot be made at all from common English pig iron; second, the manufacture of puddled steel has been much more successful on the Continent than in England; third, only mild steel and that of an inferior quality is made by this process from English iron.

Referring to the first fact, I may mention that there is a great deal of mystery, and there have been a great many failures and much waste of labor, fuel, and iron, in carrying out this process in England. In many forges where it has been tried it is now altogether abandoned, and where it is carried on with any degree of success there is usually much secrecy maintained. Now the mystery is not in the puddling, as the necessary modifications in the supply of cinder and the working of the damper are well understood, and have been sufficiently explained in the specifications of abandoned patents and otherwise. The secret part of this process is in the selection of the pig iron, or rather of the "blend" of pig iron, for it is found that a mixture of certain brands of pig iron is better than any single brand used alone.

My own experience in connection with this subject has been very interesting, and is, I think, worthy of record. When engaged as chemist in the works of Sir John Brown and Co., of Sheffield, I made care-

ful analyses of all the numerous brands of pig iron that are used for various purposes in these works. These I tabulated and kept continually before me in order to compare their composition with the special uses to which they were applied, and the properties which they or the material made from them exhibited. The manager of the iron department was a remarkable example of one of those self-taught unconscious Baconian philosophers, I have above alluded to. He has during many years been observing, experimenting, and generalizing his inductions, consisting of a code of original rules for the manufacture of iron suitable for various purposes. Like the man who had talked prose all his life without knowing it, he has been following strictly the injunction of the "Novum Organon" in discovering the best "blends" of pig iron for manufacturing respectively armor-plates, rails, boiler-plates, angle-irons, etc., etc. ; and among his other mysteries were certain blends for making puddled steel. These he calls his "steel irons." He selected these, like all the others, without having, or pretending to have, any knowledge of their chemical composition.

By quite a different path, *i. e.*, upon purely theoretical chemical grounds, I had determined that certain brands among those I had analyzed were the best fitted for making puddled steel, and was anxious to verify my theory. To have asked directly for a revelation of the iron manager's secrets would have been unreasonable, and, therefore, I simply gave him a statement of the analyses of these particular brands all arranged together, and called them "steel irons," adding that for the best work I supposed that he mixed with them a proportion of a certain foreign brand. "Hush, don't talk so loud ; I don't want these fellows to hear you. Who told you that I use these?" was the substance of Mr. Jevon's reply. My theoretical and his practical selection proved to be exactly the same in result. He had selected just those particular pigs which contained the smallest percentage of phosphorus, and which relatively to their carbon contained the smallest proportion of silicon.

But this was not all. I had just concluded a number of experiments made for the express purpose of determining the function of manganese in the manufacture of iron and steel, and had come to the conclusion that its usefulness depends upon its readily oxidizing, even before all the carbon is oxidized, and thereby affording a base with which the silica could unite and form a liquid and readily fusible silicate. Now this is just what is wanted in making puddled steel, and hence I suggested the addition of the highly manganiferous foreign ore. He had recently discovered that it did just what I expected, and supposed that his discovery was quite new. Such, however, was not the case, for this, like so many other trade mysteries, had been independently discovered by a number of other practical investigators.

The foreign manganiferous metal referred to is spiegeleisen. Dr. Percy says : "Spiegeleisen has been found admirably suited for the production of puddled steel of the best quality, and accordingly it is largely used for this purpose." Now spiegeleisen is remarkably free from those impurities which, as I have stated, cannot be removed from common English pig iron without also taking out the carbon. I find that the average proportion of silicon to carbon in English pigs is about three-fourths ; in spiegeleisen it is below one-fourth; and that the average proportion of phosphorus in the samples of spiegeleisen which I have analyzed is less than one-twentieth of the quantity contained in our Cleveland pigs. Three, four, and five hundreths per cent. is the quantity I ordinarily find in good German or Swedish spiegeleisen. The sulphur seldom exceeds one-tenth per cent., and the large quantity of manganese materially assists in the removal of the silicon. It is, in fact, very similar to the Styrian cast-iron, which, as I have already said, does not present the English difficulty of making steel by the direct process. Both are charcoal irons, made from remarkably rich and pure ores. The manufacture of cast-iron from such ores, and steel from such cast-iron, is mere child's play compared with our native manufacture.

In reference to the second fact, that the manufacture of puddled steel has been carried out more successfully on the Continent than in England, I need only say that this confirms my statements, as the puddlers there are less skilful than ours, and their raw material is a vastly superior

charcoal iron, such as I have already described.

The third fact, viz., that only mild steel of inferior quality is made by this process, is further confirmation of what I have said respecting the necessity of removing the carbon from common pig-iron in order to purify it sufficiently to produce good steel; for even with all this skilful selection of the purest pigs and the mixing of spiegeleisen with them, it is found in this country impracticable to make puddled steel containing more than one-half per cent. carbon. Such steel is only fit for rails, tyres, for rubbish cutlery, and other purposes where a very soft steel, or rather steely iron, is used. If the puddling were stopped when the carbon was only reduced to about 1.75, or (say) 1.5. per cent. (the quantity contained in the best hard cast-steel) the puddled steel would be utterly rotten, it would crush under the hammer whether hot or cold; the reason of this being that even with the best English pigs, the selected "steel irons," there would, with this amount of carbon, still remain a ruinous proportion of silicon, phosphorus, etc. It is necessary with all available advantages to bring down the carbon to within one-half per cent. in order to produce a workable material. Even then it is worth only about one-third of the price of good cast steel.

I might illustrate this subject still further by entering into the details of the chemistry of the Bessemer process and of Bessemer steel by the history of the nitrate of soda process, and of other attempts to manufacture steel directly from cast-iron; but I think the above is sufficient to expose the fundamental fallacy upon which all such attempts have been founded. I hope to have succeeded more particularly in demonstrating the very great error of those who, in their attempts to make such steel, have, like the friend of my correspondent whose letter opens this paper, deliberately chosen cinder pig or other inferior iron upon which to make their demonstrative experiments. This was the case with the Heaton Company. They worked for a long time at Langley Mill with one of the worst classes of pig iron they could have selected for their purpose. I pointed this out to them in a letter printed in the "Chemical News," of February 19, 1869. This effort, the most promising of any of the kind, on account of the action of the residual alkaline soda, was, through this serious mistake, never fairly tested. I witnessed some of their experiments, and analyzed and otherwise tested the results. There can be little doubt that with properly selected pigs a material similar to puddled or Bessemer steel may be made by this process, and by several others that have been tried and have failed; but with the common classes of English pig irons all such attempts to make steel directly by the partial oxidation of the carbon must of necessity fail, unless some entirely new, some hitherto utterly unknown method of removing the silicon, phosphorus, and sulphur of the pig iron is also used. In such a case the novelty, the invention, the triumph, would consist, not in the decarburization of the cast-iron, but in the separation of the other ingredients.

I therefore recommend all inventors who seek to simplify or otherwise improve the manufacture of steel to direct their attention first to the removal of phosphorus, next to the removal of silicon, thirdly to the removal of sulphur, and last and least of all to mere decarburization, for that is a problem of the utmost simplicity, and already sufficiently understood.

My next paper will be "On the Chemistry of the Bessemer Process," and will include some original observations, the results of which I believe to be of considerable value to the numerous manufacturers who are now erecting or working Bessemer plant.

Akron, Ohio, is largely engaged in the manufacture of various kinds of pottery ware and fire brick. A good clay bank is worth more money to a manufacturer of those wares that a coal bank is to a coal dealer. The clay industry of Summit county exceeds a million of dollars annually, without taking into account the manufacture of ordinary building brick. The sewer pipe manufacturers sell an annual average of more than $350,000. The fire brick sales amount to nearly $100,000, and the other various forms of pottery amount to more than half a million of dollars. The clay for all these wares is found in Summit county.

The Brier Hill, Ohio, furnaces are blowing out and will stop operations for the present.

GERMAN SMELTING WORKS.

From "The Mining Journal."

Nestling in the ravines of the Hartz, like the cotton-mills in the Lancashire valleys, are numerous smelting works. The frequent occurrence in the topographical terminology of blei, German for lead, and hutte, a smelting house, as Silberhutte, Frederickshutte, indicates the antiquity of the industry. Among those we visited, the works at Frederickshutte, between Zellerfeld and Goslar, were examined most in detail. And we the more readily select this for description, in that we there witnessed the working of a process for desilverizing lead, which, we were assured, is far in advance, both as regards the metal production and economy, of the Pattinson method, so universally adopted in England.

Although, as we have before intimated, there are serious objections against the Hanoverian system of working the mines and metal works directly by the State, yet there is this manifest gain, that each mine and works is able to secure a really skilful and scientific superintendence, which is more than can be said for many of our English mines. This arrangement results in a strong family likeness amongst all the mines and works, so that when one work has been examined, we find in the others precisely the same steady operations and the same stolid and enduring workmen. Each works seems to have been produced from exactly the same seed, and to differ only in the extent of its development, according to its locality and other conditions of growth. The general standard to which the ores are dressed is 75 per cent. Of this dressed ore, in the Zellerfeld Works, 66 per cent. is actually secured in metallic lead, while of the remaining 34 per cent., 13 represents sulphur, and the rest slags of various other matters present in the original ore, and loss. These amounts are by no means patent to a cursory inspection, as the matters with which the furnaces are charged are of so varied a nature, consisting not only of the picked and sieve ore, but of the impure fine ore from the jigging-tubs and buddles, containing a considerable amount of silicious matter, and of the various refuse matters from former operations, having very variable compositions.

The principle upon which the lead ores of the Hartz district are reduced is identical with the ordinary process for conducting a dry assay, and depends on the fact that iron has a greater affinity for sulphur than lead has ; a sulphide of iron is, therefore, formed at the expense of the sulphur in the galena. The general form of furnace is a tall rectangular mass of masonry, of which the slightly hollowed hearth occupies only a small portion of about 3 ft. The hearth is gently inclined toward the front, to which place the melted matters flow, slag at the top and the metal underneath. A second and lower basin, communicating with the bottom of the slag hearth, receives the lead from time to time when the workman removes the plug. The blast is supplied by bellows worked by a water-wheel. The workman pride themselves greatly on the skill with which, by regulating the blast, they can control the formation of a sort of slag-pipe that forms around the blast in the furnace, exactly like the incrustation that covers up the channel of liquid slag flowing from an ordinary iron blast-furnace. This slag-pipe, formed by the cooling effect of the blast upon the molten mass in the immediate neighorhood of the tuyere is said to be of the greatest service in preventing the too energetic action of the blast on the ores at the tuyere end of the hearth.

The usual furnace charge at the Zellerfeld Works is in the following proportions. The amounts, as given by workmen at the smelting works have been supplemented by extracts from "Regnault's Chemistry" :—Sulphide of lead, a mixture of hand-picked, sieve, and smiddim ore, 37 cwt. ; litharge, derived from cupellation, 6 cwts. ; slags of mixed nature, 43 cwts. ; cast-iron, 5 cwts. This mixture produces 24 cwts. of metallic lead. The greater portion is deposited in the receiving basin, directly from the first fusion ; but about one-eighth of the above quantity is derived from subsequent operations on the slags and matts, in manner to be presently described. The object of so large a proportion of slag in the charge is to retard fusion until desulphurization is pretty well advanced. Instead of the long

chimney-flue adopted in English smelting works, these furnaces are furnished with a series of chambers, in which the lead vapor is condensed. These are periodically emptied by means of iron doors. The contents of the receiving basin in front of the lead furnace, to which we have already referred, readily separates into two portions, the lower one consisting of metallic lead, and the upper one chiefly of sulphide of iron, with a strong percentage of lead. This matt is allowed to accumulate until there is a sufficient quantity to calcine. It is then mixed in heaps, with alternate layers of fuel, and a slow combustion is carried on for from 20 to 25 days, during which time the sulphur is driven off as sulphurous acid. When the heap has burnt out it is carefully hand-picked, and those portions not completely desulphurized are set aside to be added to the next heap, and put through the same process again, while that part of the heap which is thoroughly calcined is removed to a small furnace supplied with a good blast, where it is reduced in connection with slags and metallic iron. Here the same mixed product is obtained—metallic lead and a second matt. This matt is passed through the same roasting process, and the whole operation is repeated in the furnace until the fourth or fifth matt has become, through these successive concentrations, so rich in sulphide of copper as to be worth treatment for its extraction. In some of the Hartz works the lead is so rich in silver as to be cupelled at once. But in most cases the lead is desilverized by a process which was quite new to us, though we have since understood that the process has been tried by the Messrs. Neville & Co., at Llanelly. The lead, in ingots, is placed in a large cast-iron pot, similar to those used in the Pattinson process. When the lead is melted, and the refuse skimmed off, a quantity of melted zinc is added, equal to about 28 oz. to each ounce of silver, as shown by assay to be present in the lead. The alloy is kept in a melted state for two hours, and constantly stirred. The mass is then allowed to cool, and a thick scum forms on the surface. This scum is a mixture of zinc, lead, and silver, and after being removed to a furnace and exposed to a dull red heat for some time, to drive off the zinc, is cupelled in the ordinary way. The lead is further purified by having billets of green wood thrown in while the lead is in a liquid state. A considerable quantity of gas is generated, which gives a singular aspect to the pot of molten lead. The bubbles of gas arising and taking fire at the surface present the peculiar appearance of a blazing liquid. This was the process as we observed at Frederickshutte, but we were informed that at some works steam is driven into the melted lead, instead of adding green wood. The advantages of this over the English Pattinson process, are in cheapness, the better quality of lead, and in the higher state of concentration of the mother liquor to be cupelled. The Pattinson process does not profitably admit of concentration to more than 500 oz. to the ton, while in this process it usually reaches 1,000 oz. It seems this method was patented in England some years ago, under the name of Parke's process. It appears a matter of surprise that this plan has scarcely yet been adopted in this country. We understand that Dr. Percy intends to give a full description of this method of refining silver in the edition of his forthcoming new work on metallurgy. The advantage of this method in requiring fewer workmen is one that appeals even more strongly to the English smelter than to the German, though, on the other hand, zinc will be cheaper with them than with us.

The charges for the furnaces around Rammelsberg were given as follows :—21 cwt. of ground ore, 11 cwt. of silicious slag, 4 cwt. of lead slag, and 36 cwt. of charcoal. The blast is applied, and the reduced lead falls into the hollow of the hearth, while the slag is skimmed off by ladles. The amount of sulphur in these ores is so considerable that though they are roasted in heaps previous to being brought to the smelting-works, it is yet needful to add so much slag to prevent fusion of the ore until the chief part of the sulphur is driven off. North Germany raises 169,000 tons of lead ore annually, and manufactures 40,000 tons of metal. Of this the greater part is sold as pig-lead, but about 800 tons of it are sold in the form of sheet-lead. The produce of silver, chiefly from the ores of galena, is 148,689 lbs. troy in the year. The lead mining employs 15,784 hands, and the metallurgic refinement as many more.

THE MINERAL WEALTH OF INDIA.

The Calcutta "Englishman" remarks that India seems on the verge of losing that exclusively agricultural reputation for which she has hitherto been distinguished. The latent belief in her mineral treasures is now likely to become an active principle of Anglo-Indian life. In the Punjab there is salt enough to supply the whole Peninsula, if only it can be made available by cheap carriage. The Himalayas contain a land of silver—the Wuzeeri Roopah country ; and although they have never been properly prospected indications have been found here and there, which, if worth anything at all, would prove that they are not inferior in mineral wealth to any mountain range in the world. To say nothing of graphite at Almorah, and iron in Kumaon, the Hon. Ashley Eden thus speaks of the peculiarity of the valley of Paro, in Bhootan :—

"The soil about Paro is charged with iron to a singular extent ; by placing a magnet down on the ground anywhere in the valley it was at once covered with a kind of metallic iron dust ; by collecting a heap of sand, and working it with a magnet, a very large percentage of iron was separated from the sand. The whole hill sides above were yellow, and were apparently full of iron. There is an iron mine about two days' journey from Paro, and the Bhooteas declared that they obtained lead from the same mine, but in small quantities. It is certain they do obtain lead to a small extent in their country."

When we turn from the Himalayas to Central India we come upon a mineral district, which, commencing within 100 miles of the capital, stretches for an unknown distance toward Bombay. To the south, the discovery of coal at Chanda may be said to extend to the valley of the Godavery ; while to the west, the Nerbudda Coal and Iron Company have opened workings at Morpani, close to the eastern borders of Bhopal. Besides this vast field, the trans-Megna districts produce coal of an excellent description. Seams of from 4 to 6 feet in thickness have been worked at Chena and Lacaday, in the Khasia and Jynteeah hills ; and on the banks of the Dehing, in upper Assam, there are numerous out-crops of perhaps the best coal in India. In the valleys on the eastern side of Central India are found gold and a variety of precious stones. Far away to the west, in Bundelkund, the Rajah of Punnah has a few diamond mines, and the plateau of Rewah is known to abound in the most valuable ores ; there are gold and gems in the streams, copper in Manbhoom, and iron almost everywhere. At Mahemmedpore, near Soory, within a few miles of the Cynthia Station of the East Indian Railway, rich, though somewhat intractable, iron ore is found, and we believe that it is no secret that at Jamalpore a valuable paint has been made from ironide of iron, sent down by the engineers employed on the Allahabad and Jubbulpore line. As for coal, following what seems to be almost a law, wherever iron has been found, there also has coal been discovered. Perhaps a better estimate will be formed of the extent of the coal deposits of Central India if we refer to the map. Coal there has been found over an area of at least five degrees of longitude in breadth, by four degrees of latitude in width—that is, from Midnapore to Mopani, east and west, and from Kurkurbaree to Chanda, north and south. Here, then, in the very heart of India, we have an immense "black country," a country of hills and vales, and lofty plateaus, where cotton grows luxuriantly, and where immense plains produce fabulous quantities of grain.

The prospect held out to India is, shortly, that a cotton-growing country shall also be a cotton-manufacturing country. At places like Khandalla, on the Western Ghauts, Europeans can not only live, but flourish in a healthy mountain climate, and here on the margin of the great cotton districts of Berar, Chanda coal could be put down at a rate which would beat English mineral fuel out of the field. Hitherto, again, the iron ores of India have been neglected, because of the difficulty in procuring good fluxes. But with open lines of railway it only requires the discovery of a good bed of lime to find the ore travelling in the rough state to points where it can be usefully worked. The necessities of a great railway system will speedily make it as imperative to use Indian iron as it is now to use Indian coal ;

and when that day comes the Central Provinces, which have a population devoid of many prejudices and ready for the work, will enter on a new and unexampled career of prosperity, and furnish the Government with new sources of strength and new guarantees of the stability of British rule.

THE STRASBOURG CLOCK.

From "The Mechanics' Magazine."

The great clock at Strasbourg is one of the wonders of the world about which travellers are often apt to romance a little, making it out more wonderful than it really is. But for all this, it is an extraordinary piece of mechanism, and its performances entitle it to rank high in the records of horology. All those who pass through Cheapside witness hourly—nay, four times an hour—with some degree of wonderment the activity of a set of figures which strike the chimes and the hours outside the house of one of our most enterprising citizens. But these are wonderfully simple operations as compared with those of the celebrated Strasbourg clock, of which the good citizens are justly proud. Before detailing these performances and describing the clock, it may be as well to refer to the history of this ingenious piece of mechanism. The clock stands in the Cathedral, its origin dating as far back as 1352, in which year it was put up under the patronage of Berthold de Buchek, then Bishop of Strasbourg. Of the artist's name nothing appears to be known; he must, however, have been considered a prince among clockmakers in his day, for the clock appears to have been a highly successful work of art for the period. It was divided into three parts, the lower portion exhibiting a universal calendar. In the middle part was an astrolabe, and in the upper division were the figures of three kings and the Virgin carved in wood. At the striking of each hour the three kings bowed to the Virgin, whilst a carillon carolled a cheerful tune, and a cock crowed and clapped his wings. In course of time, however, this clock got out of order, and in 1547 its repair was committed to the charge of Dr. Michael Herr, Chretei Herlin, and Nicholas Prugnor, three mathmeticians of repute. They died before their work was finished; but it was taken up by Conrad Dasypodius, a pupil of Herlin, and who completed his task in four years. The clock went well until the year of the great Revolution, when it struck for the last time.

Nearly fifty years passed, during which time the great clock gradually fell into a very dilapidated state. It was then resolved once more to restore it to its former working condition; but this was found to be impossible, as the works were eaten up with rust and verdigris. At length one Schwilgue, an artist and mathematician of Strasbourg, offered to repair, modify, and reinstate the clock; which task, it is recorded, he commenced on June 24, 1836, and finished in four years from that time. It is stated that Schwilgue received an order to construct a similar clock for a cantonal capital in Switzerland; but his townsmen, jealous of the horological fame of Strasbourg, put out his eyes, and thus prevented him fulfilling the order. We have no authority for this statement, and therefore can only consider it in the light of one of the traveller's tales to which we have already alluded.

The mechanism of the new clock was placed by Schwilgue in the old casing, the number of the figures having been increased, and their appearance being improved by jointed limbs. The quarter chimes are struck by figures representing the four ages of man, which move in a circle around a skeleton mower. The hour bell is struck by a Genius, a figure of an angel at the same moment turning an hour glass, through the narrow neck of which the sand is kept perpetually running year after year. Every day at noon a procession of the twelve apostles takes place around a figure of the Saviour. Each one in passing inclines towards the central figure, which, when the circuit has been made, extends its hands as in the act of blessing. During the procession a cock flutters his wings, opens his beak, and crows three times. The clock shows the month, and the day of the month, the sign of the Zodiac, the Dominical letter, the sidereal time, the Copernican planetary system,

and the procession of the equinoxes. Its mechanism is so perfectly elaborated that it marks the twenty-ninth day of February in every leap-year. With this perfection of detail, no wonder that the citizens of Strasbourg are proud of their Cathedral clock, and no wonder either that travellers are neither slow to visit it nor to enlarge its performances to an extent somewhat beyond its real capability.

THE PRESERVATION AND PURITY OF IRON.

From "The Builder."

But few subjects connected with the craft of the builder, the work of the mechanical engineer, or the labor of any workman who is concerned in the manufacture or the preservation of iron-work, have more importance than the question, "What is rust?"

"Why, every one knows what rust is," many a reader may reply. "It is impossible to read any work touching on this subject, without becoming aware that rust and oxide of iron are used as equivalent terms."

Such, no doubt, is the general view; but the use of language, however, general, is by no means a proof of the accuracy of the statement (the truth of which is taken for granted), that the destructive action which we call rusting is nothing else than the oxidation of iron by exposure to damp and to the atmospheric air; or, in other words, that rust *is* the oxide of iron.

It is obvious at a glance that this is not a mere curious question of speculative chemistry. It is not a pedantic quarrel about words. Rust, whatever may be the etymological affinity of the word written in Latin, *rubigo*, is good, plain, vernacular English. We all know what the word means, to a certain extent; and we all of us have more or less suffered from the liability of iron-work to be deteriorated by its attack.

But the main importance of knowing what rust actually and chemically is, is not literary. It is eminently practical; for thus alone can we arrive at the answer to the yet more urgently practical question, "How shall we preserve iron from rust?" If we mistake the nature of the evil, we shall not be unlikely to mistake the nature of the remedy.

Before entering into the investigation of any chemical hypothesis on the subject, let us call attention to the result of an experiment made recently by an eminent chemist, with a view to determine the nature of the action which generates rust.

Two pieces of soft iron, of equal dimensions, were filed up smooth and bright. A solution of bicarbonate of soda was placed in a test tube. A portion of the same bicarbonate was placed in a crucible, and subjected to a heat which rendered it caustic, and a solution of this caustic soda was placed in a second test-tube. One of the pieces of iron was placed in each tube. The first of these, that placed in the ordinary solution, instantly began to rust, and continued to evince the active progress of that destructive process. The latter remained quite bright.

It was left in the solution for about six months, towards the close of which period it began to show symptoms of chemical action, and finally rusted like the companion specimen.

The cause of the behavior of the iron in each instance is made perfectly intelligible on the theory that the red, destructive rust is not, as ordinarily imagined, an oxide of iron, but a carbonate of the sesqui-oxide ($Fe_2\ O_3\ C.O_2$). On this view the presence of carbonic acid is necessary for the production of rust. The bicarbonate solution ($Na\ O.\ 2\ C.O_2$), was readily decomposed, and set at liberty the carbonic acid and oxygen to attack the iron, which, accordingly, immediately began to rust. But when this equivalent was driven off by heat, the iron placed in the caustic solution was not in a position to attract carbonic acid, and therefore did not rust. Its freedom from destructive action continued until the solution, being left in an unstoppered tube, had attracted enough carbonic acid from the atmosphere to lose its causticity. The moment that enough carbonic acid had been absorbed by the solution for it to *spare* some for the iron, rusting commenced. The experiment is extremely elegant, and it is diffi-

cult to resist the inference which is drawn from its results.

The view that the corrosive rust of iron is, like that of copper, a carbonate, accounts very clearly for the destructive action which takes place when iron is set into stone-work, or in any way wedged into buildings surrounded by mortar. The chemical change which takes place in the drying and hardening of mortar is, after the first short period of setting, extremely protracted. During the whole of this slow process carbonic acid is at liberty to attack the inclosed iron, and hence arises that thickening sort of rust which, almost as if with the growth of vegetation itself, slowly and irresistibly acts as a destructive wedge.

Iron may, however, be used in the interior of buildings with perfect safety, if it is protected from the access of carbonic acid. A remarkable instance of this occurred, as a piece of practical experience, on the demolition of the Wriothesley-street Bridge, on the London and Birmingham Extension Railway. This bridge was erected in 1835. Like the Hamstead-road and the Park-street bridges, it consisted of brick abutments, pilasters, and piers, supporting cast-iron girders, between which were brick segmental arches, *set in Roman cement.* On the pulling down of this bridge for the extension of the Euston station, it was found extremely difficult to separate the brick-work from the girders. It was as easy, or more so, to break the bricks themselves. But when the separation was effected, it was found that this unusual adhesion was caused by the entire *absence* of rust. The blue scale remained uninjured on the face of the metal,—red incrustation there was none. This blue scale, no doubt, *is* the oxide of iron, which forms, as in the case of other oxides, a coating of a protective character. The confusion of this harmless oxide with the destructive carbonate is an error of no trivial importance; and its detection bids fair to lead to the reconsideration of the entire subject of the protection of iron-work from rust.

Closely connected with the question of the action of carbonic acid on iron is the investigation of the facts, which at present seem to be so anomalous, observed as to the intimate union of carbon and of iron in cast-iron and in steel. Why the elimination of a small proportion of carbon from the metal (or alloy) should be accompanied by such an increase of power of resistance to tensile strain, and why the reintroduction of a yet smaller proportion should be attended by so much more considerable an increase, is a mystery of economic metallurgy which it is of extreme importance to solve. The entire question of the behavior of steel is one requiring much elucidation.

That steel, under certain conditions, evinces a metallic tenacity, and power of resisting fracture, of the very highest degree, is evident from the effect of impact on steel shell, when fired at armor plate. The action of that sudden and terrible blow, which shatters the case-hardened iron shot, is like that of the blacksmith's hammer on a bar of cold iron, dexterously manipulated on the anvil. We know that iron can thus be hammered till it is hot. The steel shell, in like manner, is heated until it actually explodes its contents. At the same time the head of the projectile is hammered out of shape; but no fracture takes place. The tremendous force of the blow seems to be converted into thermometric, or rather pyrometric heat; and the steel, thus heated, forges as beneath the steam hammer. The property of steel shell was discovered by accident, a fuse having been picked up on the practice ground when there had been no blind shell fired; but, thus discovered, it has been made use of for the purpose of exactly timing the explosion of the projectile.

On the other hand, we have the fact that a steel armor plate, prepared with the utmost care for the purpose of experiment, tempered in oil and produced with the full expectation that it would evince a power of resistance never previously developed, was fractured, and speedily put *hors de combat,* by the comparatively trifling assault of a 68-pound shot. This difference in the behavior of steel as hammer and as anvil, as projectile and as armor plate, is, as yet, entirely unexplained.

The interest of these inquiries is not merely philosophical. It is practical in the highest degree. So long as we are aware of the existence of facts, quite unexplained, but in which the most (apparently) inadequate causes produce the most extraordinary results, we are in the position of people who are on the brink of a discovery. How brilliant that discovery may

be, we cannot tell. We are on the scent of a treasure trove, but we can only guess at the size of the crock of gold. Mankind has made use of iron for at least four thousand years, for fragments of iron tools have been found in the Great Pyramid, left by the original builders. How long was it before iron was turned into steel? And, even at the present day, while producing iron by millions of tons, and paving our railways with steel, we are discussing the chemical action which produces rust, and we are entirely ignorant of the intimate cause of the differences between iron and steel, so far as regards the effect of the dose of carbon.

It is stated by Sir W. Armstrong that both in the Elswick and the Woolwich guns whenever failure takes place, it almost invariably originates in the part which is made of steel. The steel tube is the part that cracks first. Steel vent pieces, which were first employed, were fractured with alarming frequency ; but since iron ones have been substituted, fractures have been rare. It is argued from these facts that the vibratory action attending concussion is more danger us to steel than to iron.

The peculiarity of the case consists in the apparently contradictory behavior of steel when used as a projectile, as a gun, and as a target. It is quite true that, in all manufactures of iron, the two opposite qualities of hardness and of toughness have to be considered. We are not so ignorant of the practical part of this branch of metallurgy as to be unaware of modes of tempering, and of annealing, and generally of producing a metal suitable to the purpose in view. But what we *do not* understand is the law which regulates the existence of these properties. Our knowledge on the subject is almost entirely empirical. The tensile strength of wrought iron is considered to be due in great measure to the removal of the 4 or 5 per cent. of carbon which is contained in cast-iron. The formation of laminated fibre by hammering, no doubt, has much to do with the change ; but the chemical difference is important. Yet when iron is made into steel, the tensile strength of the latter is increased by the addition of carbon up to the proportion of some $1\frac{1}{4}$ per cent. With this very increase of tensile strength, however, contrary to all analogy, we find an increase of brittleness to coincide. For resistance to impact, it is considered that steel cannot contain too little carbon. That hardness and brittleness should increase or diminish together is not matter for surprise ; but analogy would lead us to expect a different result to accompany the increase of tensile strength.

There is no doubt whatever that the great foe to the excellence of iron is impurity, especially the presence of sulphur. Our enormous production, and the commercial rivalry which has proven so strong a temptation to the manufacturer to study cheap modes of production, irrespective of their influence or quality, has deteriorated our iron to a lamentable extent. English axes are said to be useless in the forests of America, or against the iron-barked trees of Australia. The difficulty of producing, from the present wrought iron of commerce, anything approaching the excellence of the old English forged work, has been illustrated, within the past few months, by the high praise given, by very competent judges, to some specimens of smiths' work to which prizes were awarded by the Society of Arts the other day. If these prize specimens be compared, not only with the Hampton Court gates, forged in 1695 by Huntington Shaw, and preserved at South Kensington, but with such samples of neglected and unknown old English work as may now be seen in the course of rapid decay before an old house in the main street of Rochester, we cannot fail to deplore a sad decadence in the art ; the fault, no doubt, as well of the iron-master as of the smith.

It would probably be impossible for any English smith now to produce such work as some of the later specimens of articulated armor in the Tower of London. On the other hand, where, for special purposes, special attention has been given to the manufacture of the iron, the result is satisfactory. We question whether either Toledo rapiers or Damascus sabres would stand uninjured, taking them one with another, the rude tests to which Mr. Wilkinson, of Pall-mall, subjects his best swords. It is true, that of these carefully made blades, we have seen three out of four damaged in the test. But the one which passes is a weapon to which a man may safely trust. If any corslet now worn in European warfare resists its thrust, it is the fault, not of the blade, but of the arm that wields it. In preparing iron for spe-

cial purposes, the chemical character of the water used in the factory appears to be very important. It was an old by-word in the steel trade that a good sword could not be made at Sheffield, nor a good knife at Birmingham, the sword being the boast of the latter town, and the knife of the former.

The practical upshot of these considerations ought to be, the concentration on the subject of the chemical properties of iron and carbon in combination, of the same kind of clear, patient, proposed attention as that which has thrown so much light, within the past few months, on the question of the propagation of disease by germs floating in the air. An immense amount of empiric inquiry is going on upon the subject. Great practical results have been attained. We need not particularize any of those processes as to which no small amount of controversy has recently raged. We are not undervaluing the labors of such men as Whitworth, Brown, Siemens, or others. Still, while the action of carbon in its relation to iron is so apparently capricious and contradictory, and while the destructive effect of carbonic acid, and the actual nature of corrosive rust, have been hitherto almost entirely unsuspected, we cannot doubt that a great reward, in fame at least, if not in gold, will atten the success of that scientific investigator who shall unveil the true law of the relation which subsists between the material which forms the hardest and the most precious of gems, and the mineral which, all things considered, may be pronounced the most valuable of metals. The Victoria cross of science awaits the discoverer of the law of the combination of carbon with iron. The fact that the presence of phosphorus produces "shortness" or brittleness in iron when cold, while that of sulphur has the same effect at a red heat, is another of those anomalous, and apparently capricious differences which chemistry has detected, but not explained.

Very closely connected with this part of the subject is the extremely important question of the influence of mineral or of vegetable fuel on the reduction of iron ore. So far from this being a mere matter of chemical curiosity, it is one which is most intimately connected with our national prosperity. It is well known that iron was originally smelted in England by wood, and that, under these circumstances, beds of ironstone, which are now entirely neglected, in consequence of their distance from the great coal basins, were advantageously worked. In the present state of the country, of course no fuel can be obtained except coal. In 1866, it is estimated by the Mining Record Office, 9,665,000 tons of iron ore were raised, and 4,530,000 tons of iron were produced, in the United Kingdom. The quantity of coal consumed in the 613 blast furnaces which smelted this total quantity of pig iron is not stated. The total quantity of coal raised in the year 1866 is set down as upwards of 101,500,000 tons. The iron made in England at present, or, at least, in 1866, was very nearly half the total make of the world, which is estimated for the preceding year, 1865, at 9,500,000 tons. We shall probably be under the mark in setting down 15,000,000 of tons of coals as consumed in our smelting furnaces. The average value of English coal, at the pit's mouth, is taken by the Mining Record Office at 5s. per ton, which would give something like 15s. for fuel for smelting a ton of coal.

In Russia charcoal is still almost exclusively used for smelting; and as to the superior quality of the iron thus produced there is no question. Nor as to the mere element of the cost price of production is the difference so much in favor of the inferior quality of metal as to lead us to entertain any very great confidence as to the permanent position which our ironmasters will occupy in Europe. From recent and very carefully collected information as to Russian iron-works, we find that iron is now produced by the consumption of 110 tons of charcoal to 100 tons of iron made. The lowest price of birch charcoal in Russia is 6s. 6d. per ton; 8s. 2d. per ton is considered a cheap purchase; and 14s. 9d. per ton, and even more, is paid in some establishments. As this variation in price, however, is almost all due to the expense of land-carriage, there can be no doubt that the service of the great iron-works by light railways, which can be laid and relaid year year after to the portions of the forest from which the supply is taken (on the principle of allowing from sixty to eighty years for the regrowth of the timber), will keep down the cost of charcoal for smelting, something below 10s. per ton of iron.

We have not space to exhaust this important subject at present. One thing seems to us to be clear, and that is, that unless the attention of our practical and scientific chemists is turned to the purification of iron smelted by mineral fuel, to the elimination of sulphur and other impurities, and to the elucidation of the complete scientific theory of the relations existing between iron and carbon, the time cannot be far distant when our blast-furnaces will be blown out one by one ; and when the excellent charcoal iron which Russia can produce in any quantity, and at moderate prices, will replace Scottish, Welsh, and English metal in the market.

WROUGHT IRON AND STEEL—THE FLUO-TITANIC PROCESS.

In the April number of this Magazine is an article on the production of wrought iron and steel by the Fluo-titanic process, invented by Mr. James Henderson of this city.

At that time the experimental operations had been conducted only in the laboratory. Since then experiments have been made on a large scale at Messrs. Park Brothers and Co's works in Pittsburgh, in puddling furnaces, but without puddling, or the labor of stirring the iron during conversion ; the only labor was that of "balling up" the wrought iron, and removing it from the furnace after the conversion was completed. The results obtained then, and also since, with red hematites at other works leave no doubt that it will produce iron for castings much stronger than any heretofore produced, or steel of any required quality, or pure wrought iron.

The mode of treatment in the above-named establishment was, by mixing the titaniferous iron ore and the fluorspar both in a powdered state, and then charging them upon the sole of the furnace. Gray pig-iron was then charged upon them, and when melted, was allowed to remain without stirring or puddling ; as soon as the pig-iron melted, reactions began between the fluorspar and titaniferous iron ore and the silicon, phosphorus, sulphur, and carbon contained in the pig-iron.

To ascertain exactly the conditions upon which the changes are made in the cast iron, whilst under treatment, samples were taken from the bath of liquid iron at intervals whilst under treatment. The analysis of the first sample taken from the bath shows that the operation of the new process is entirely different to any other process, inasmuch as the silicon is entirely removed at the early stages of the process, and, with the silicon, phophorus is also taken from the iron, and the carbon is changed from the graphitic to the combined form.

The analysis of the first sample has been made by Mr. W. M. Habirshaw, analytical chemist, of 36 New street, in this city, and is annexed; analyses of Sanderson's and Krupp's cast steel, taken from Percy's Metallurgy, are also given for comparison.

Henderson's Refined Cast Iron.		Sanderson's Cast Steel.		Krupp's do.
Comb'd carbon	2.7144	not deter.	..	1.18
Graphite	traces	.....	..	....
Silicon	0.0046	0 24	..	0.33
Phosphorus	0.0349	0.02	..	0.02

The other samples, taken at later intervals, have not been analyzed, as the analysis of the first sample made it evident that the later ones differed only in respect of the less amounts of combined carbon and phosphorus they contained. This has been confirmed by treatment of them as steel, it having been found that they possess the properties of steel, forging well, and tempering and hardening according to the various degrees of carbon contained in them. At the end of the operation the charge became wrought iron, by the removal of *all* the carbon. This iron forges, welds, and is neither cold short nor hot short. It was tested at the Fort Pitt Iron Works, in Pittsburgh, for tensile strength and elongation, as follows :

Specimen No. 1.—Short, for tensile strength, turned down from $1\frac{1}{4}$ in. sq. to dia. 63″, gave tensile strength of 68.952 lbs. per sq. in.

Specimen No. 2.—Long, elongated from 9″.4 to 11″.24 before breaking. The diameter of this specimen was reduced from .635″ to .452″.

Upon comparison of the refined cast

iron with Sanderson's and Krupp's cast steel, it will be evident to the practical metallurgist that every particle of the phosphorus in the refined cast iron will be removed during the subsequent oxidation of the required carbon, to form steel, and the working the ingots into marketable shape. No analysis of sulphur is given in this case, as the pig-iron used is known to contain but traces of it.

Heretofore, all processes have failed to remove the silicon entirely from the cast iron. And, as the sulphur and phosphorus cannot be removed until the silicon is acted upon, and the other processes fail to thoroughly remove the silicon, it has never been economically practicable to make superior steel and wrought iron, except by using pig-iron free from sulphur and phosphorus, and containing very little silicon. This has been owing to the fact that but *one* agent, oxygen, has been used. This agent has as great an affinity for carbon as for the other elements in the iron, consequently it has been necessary to remove *all* of the carbon, and form wrought iron in order to remove the other impurities. This defect in the old processes is entirely remedied in the new process, which consists in using *two* agents, viz., fluorine and oxygen, one of which—the fluorine—having greater affinity for silicon, and acting more energetically upon it than oxygen acts upon carbon, removes *all* of the silicon from the iron before the oxygen has time to combine with the carbon.

In the earlier stages of the new process, there is no waste of iron by scorification, as the silicon and phosphorus pass off in the form of vapor, and the only loss of weight attending the operation at this period is the weight of the silicon and phosphorus. Experiments made with the new process in crucibles, to produce steel and wrought iron (at temperatures 1,000 deg. higher than in the puddling furnace used for the larger experiments), have yielded considerably greater weight of wrought iron than the weight of the pig-iron used. These gains are due to the reduction of the iron in the oxide to the metallic state, and its incorporation with the rest of the metal.

There is no doubt that with a properly constructed reverberatory furnace in which a heat of 3,800 deg. can be kept, steel and wrought iron may be produced cheaper and better by the new process than by any other process in use.

Interesting experiments have been made with fluorspar and hematites for refining pig-iron, and will be made the subject of another article. H.

TESTS OF METALLIC BRIDGES.

Translated from "Revue Industrielle."

There has been hitherto no definite and settled official rule for testing metallic bridges on common roads. Sometimes the old rule is adopted of submitting the bridge to a uniformly distributed load of 400 kil. to the square metre.

A late circular contains tests well defined, as follows :

(1.) Metallic trusses should give passage to every vehicle authorized by the regulation of August 10, 1852 ; that is, to vehicles drawn by not more than 5 horses if they have two wheels, and by not more than 8 if they have four wheels ; 11 tons load is allowed for two-wheel wagons and 16 tons for four-wheel wagons.

(2.) The dimensions of the parts are calculated so that the work of the metal per square millimetre under the maximum load is limited to 1 kil. for cast-iron working by tension ; to 5 kil. for cast-iron working by compression ; to 6 kil. for wrought or plate-iron, both for tension and compression.

Higher figures are permitted for large bridges, when justified by quality of metal, form, and disposition of pieces.

(3.) Each metallic bridge is subjected to the following tests : The first, by load uniformly distributed, is made by an additional load of 400 kil. to the square metre of floor, footway included. This load should remain for at least eight hours, and in every case until depression has ceased.

The second proof is for rolling road, and is made with wagons of two or four wheels, with maximum load, teams attached and walking. These are to move close, in as many files as the carriage-way

will allow. All should then stand on the floor for half an hour.

These regulations, made because of late accidents, will make the construction of metallic bridges more onerous than hitherto, especially for small structures. For large works above 20 metres long, there will be no difference.

A VISIT TO THE BESSEMER WORKS AT TROY.

At the late meeting of the American Association for the Advancement of Science, the members, by special invitation, visited the Bessemer Works of John G. Griswold & Co., a short distance below the city. The following excellent description of the process exhibited at the time was written by R. W. Raymond, Esq., U. S. Commissioner of Mining, for the columns of the "Evening Post":

There is a good deal of nonsense talked about the Bessemer process. Its product is frequently compared with cement or blister steel, and with cast steel, whereas it is neither chemically nor physically steel at all, but a very pure, homogeneous, somewhat highly carbonized wrought iron. This fact was admirably brought out in the paper of Lieutenant Dutton, read before the Association, and summed up in the words that the Bessemer, or pneumatic process, is a method of making cast wrought-iron. It is to be compared, therefore, with the puddling process, from which it does not essentially differ in chemical reactions, though the two are as unlike in mechanical means as could well be conceived. In puddling furnaces the oxidation and removal of the impurities of the pig-iron are effected by a reverberatory flame, accompanied by constant stirring of the charge. The great trouble is, that as the carbon burns out of the cast-iron and it approaches the condition of wrought-iron, the fluidity of the charge rapidly decreases, since the melting point of wrought-iron is considerably higher than pig—too high, in fact, for the temperature of the puddling process. Consequently, the iron coagulates and segregates in granules and lumps, like "butter out of the buttermilk in a churn," as Dutton well says. The spongy masses which finally result cannot possibly be as homogeneous as fluid, and even after passing through the squeezers, to express the enclosed impurities, may still contain portions of slag, besides which their consolidation by pressure into workable shapes cannot be so complete as that effected by a cast.

The Bessemer process effects both the mechanical stirring and the chemical purification (oxidation of carbon, silicon, etc.), by the agency of a powerful blast of air passing through numerous small perforations in the bottom of the converter; and this blast, at the same time, maintains throughout the process an enormous temperature, rising sometimes to 5,000 deg. Fahrenheit, by which an extreme fluidity of the charge is secured at every stage. The product, therefore, is directly cast into moulds, and requires no further purification.

The use of ferro-manganese, or spiegeleisen, at the conclusion of the heat, is what has led to the popular notion that the product of the pneumatic process is steel. The spiegeleisen does, indeed, reintroduce a small amount of carbon into the almost entirely decarbonized iron of the fluid charge, but this amount is far too small (at the Troy works only about one-fifth of one per cent.) to entitle the result to the name of steel.

QUALITY OF THE BESSEMER METAL.

There is little significance in names, however. The great point is, that Bessemer metal is better adapted than steel to resist many kinds of strain. This is especially true of railway strains, which true steel would but poorly resist. The recent absurd dictum of the "Tribune," that the Bessemer product is a failure, because it will not make good tools, shows how dogmatic is ignorance. If it were fit for tools, it would be the worst possible material for rails. If the Bessemer metal is called steel, it must be described as a very soft variety, containing but one quarter of one per cent. of carbon.

HOW THE WORK IS DONE.

But I set out to give you rather a description of the works than a discussion of the method. A large party of us availed

ourselves, the other day, of the cordial invitation of Mr A. L. Holley, the manager of the Bessemer works of John A. Griswold & Co., to witness a Bessemer "heat." As we entered the converting-room, 110 by 90 feet in size, with a lofty roof, the workmen were engaged in hoisting out of the moulds the glowing ingots from a previous heat, and depositing them on the sandy floor to cool, or loading them upon a railway truck for removal. The lifting was performed by cranes, which seemed to operate without direction, and, with almost superhuman intelligence, now descending and now rising or turning, as the handling of the 1,400 pound ingots required. Soon we noticed at the further end of the room an elevated platform, with a railing, behind which was a row of brake-wheels like those on a railroad car. Here stood several workmen, their hands upon the wheels, and the vigilant eyes of each upon the distant crane, which it was his business to control and guide. Thus, with a touch of the hand, the power of the hydraulic machinery was communicated to the lift. The pressure on the water used in moving the seven lifts and cranes and the two huge converters, is 300 lbs. per square inch. It is not too much to say, that without the aid of hydraulic machinery, the Bessemer process would be economically impossible.

THE CONVERTERS.

Our attention was at once attracted by the two five-ton converters. It is difficult to describe these so as to give a clear notion to one who has not seen them, but I will make a desperate attempt. Imagine a huge iron vessel, $14\frac{1}{2}$ ft. high and 9 ft. in diameter externally, cylindrical in form at the middle, and contracting in hemispherical curves above and below. The lower hemisphere is truncated, giving a flat bottom, say 5 or 6 ft. in diameter, of which more presently. The upper hemisphere terminates in a large neck inclined sidewise, so that a flame issuing under pressure from the mouth would not be vertical, but obliquely directed; and, when the converter is in an upright position, the flames will enter the chimney, guarded by a hood. The whole vessel has a rude resemblance to a pear. It is supported by heavy trunnions on each side of the centre, and revolved upon these by hydraulic power. A boy at one of the wheels on the remote platform before mentioned, swings the ponderous mass about its axis with ease, performing, by the aid of machinery, the work of 50 men.

We may consider the converter as a huge iron bottle, with its neck awry, lined with a foot of refractory silicious material, and rotating at will upon an axis at right angles with its length. It is in this bottle that the melted pig-iron is to be exposed to a fierce agitation and oxidation by means of a blast of air, and thus, the carbon and silicon being burned out of it, converted into malleable iron. Evidently the only place where the blast can be introduced is through the trunnions, since these are the only points in contact with the solid supports. Accordingly, the trunnion is hollow, and a passage from it runs down the outside, looking like a strong rib in the iron surface, to the bottom, where it communicates with the tuyeres. The bottom of the converter is movable (an improvement introduced to facilitate repairs by Mr. Holley), and when taken out looks like a great plug of fire brick, 2 ft. high, resting upon a cast-iron disk. The tuyeres, or nozzles for the blast, are imbedded vertically in the lining, and present 10 groups, each containing a dozen three-eighths inch holes. The aggregate area of these openings is equal to that of a single tuyere 4.1 in. in diameter, but the thorough agitation produced by dividing the blast secures much greater useful effect. The pressure of the blast is 25 lbs. per sq. in. "This mechanical action," says Mr. Holley, "the numerous and violent air-blasts as a means of promoting the chemical reaction, is the essence of the Bessemer process."

When we arrived, one of the great converters was turned on its side, and we could see into its red throat. It was cooling down a little, preparatory to the removal of the burned-out bottom and the insertion of a new one. The other was moderately spouting fire, undergoing the reverse process of heating up, preparatory to a blast. In a few minutes the interior was hot enough, and the unwieldy monster, turning its mouth downward, vomited out the glowing coals which it had been digesting. Then it turned upon its side, and the end of a trough was brought opposite its fiery lips. This trough we could trace back, up a steep incline to the half distinguished breast of a cupola furnace

on the floor above. An instant more, and a white stream of molten iron comes leaping down with coruscating showers of starry sparks, and plunging into the mouth of the converter. (The position of the vessel at this time prevents the charge from running into the tuyeres before the blast begins. Afterwards the pressure of the air itself keeps the passage clear.)

INTENSE HEAT AND LIGHT OF THE BLAST.

Then the blast was let on, and the converter swung back to a vertical position. A tongue of white flame came roaring out of the mouth, dazzling our unaccustomed eyes. But neither the brilliancy nor the temperature of the flames was as great at first as they became shortly after. The silicon of the pig oxidizes first, without very intense flame; but as the graphite, and especially the combined carbon, begin to burn also, the heat rises to some 5,000 deg. Fahr., and the light is so brilliant as to cast shadows across full sunshine. A professor in our party had brought a spectroscope, through which we examined the flame with curiosity. The principal line indicated was that of sodium, which must have been due to the material of the lining. Some other lines flashed out momently, now and then, and disappeared, masked in the continuous spectrum of the white-hot gases.

In 15 or 20 minutes, the marvellous illumination ceased more suddenly than it had begun. The volume and brilliancy of the flame diminish together with startling rapidity. So great is this almost instantaneous change, that it can be discerned "in the night time," says Lieut. Dutton, "at a long distance from the foundry, and from any position commanding a view of the tall chimney, or even of the glare from the doorways, no direct view of the flame being necessary." This change of the Bessemer flame is still a puzzle to chemists. It does mark, it is true, the elimination of most of the carbon, but not of all; and it is inexplicable that the combustion should cease so suddenly while there is yet fuel left. Theory apart, however, the critical moment in practice is indicated by this change. When it arrives, the blast is stopped, the converter is turned upon its side, and 600 lbs. of melted spiegeleisen are turned into it, as the pig was previously charged. The reaction is instant and violent. The manganese of the spiegeleisen combines with any sulphur that may remain in the bath, forming compounds which pass into the slag. It also decomposes in the slag silicates of iron, taking the place of the iron and returning it to the bath. Finally, the carbon and manganese together reduce the oxide of iron formed during blowing, which would destroy the malleability of the iron.

THE DISCHARGE.

All this is done in shorter time than I occupy in describing it; and now the gigantic converter, like a monster weary with drinking boiling iron and snorting fire, turns its mouth downward, and discharges its contents into a vast kettle, or ladle, brought underneath for the purpose by one of those intelligent cranes, that stand around so silent and so helpful. The ladle is swung over the moulds, and the white, one would almost say transparent, metal is drawn off into these through a tap-hole in the bottom. The heat is over. Five tons of cast wrought iron (or soft steel, if you will) have been made in 20 minutes. The actual production of these works is 1,000 to 1,200 tons of ingots per month, which is nearly twice as much as that of an English plan of the same capacity of converter. The difference is due to the admirable arrangements and improvements of Mr. Holley, which greatly reduce the loss of time in repairs and handling. The number of workmen now employed is 200. The capacity of the whole works, when the blooming-mill is completed, will be about 18,000 tons of blooms per year.

THE "Miner's Journal," of Pottsville, says if all the anthracite collieries were in full work, coal would fall to $2.25 per ton at the mines. To prevent this decline, the owners and operators of coal mines hire the operators to strike, a great portion of the summer season, and then when the cold weather comes, advance the price of coal because the stock is light. This enables us to account for the high price of coal.

THE Hopewell furnace, Bedford county, is now producing 40 tons of the best charcoal iron weekly.

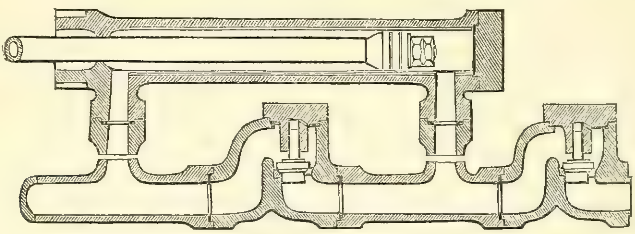
TRANSFER OF POWER—ACCUMULATOR SYSTEM.

From "The Mining Journal."

This system furnishes the means of transferring from one point to another an accumulated amount of power, and of applying it to rotary or reciprocatory purposes. The apparatus consists of a prime mover in the form of a steam or water engine, a set of charging pumps, a large plunger with weight box, a main of pipes, and pumping or winding engines. The pumping-engine used for charging the accumulator consists usually of a pair of horizontal steam cylinders. with two force pumps, which are supplied with water from a cistern set in the engine-room. Instead of employing single-acting charging pumps double-acting ones may be used as shown in Fig. 1.

In this arrangement the out-stroke of

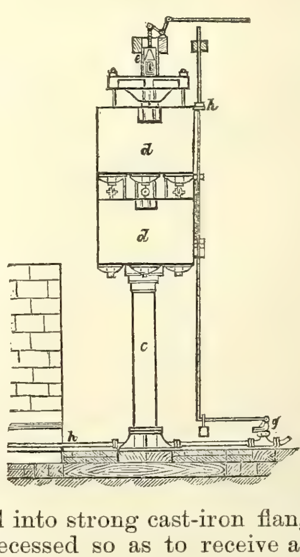
Fig. 1.



the pump causes the water contained in the annular space surrounding the plunger, *a*, to be forced into the pipes, while a further supply of water enters behind the piston, *b*, through the suction-valve, *d;* in the in-stroke the water behind the piston is discharged through the delivery valve, *c*, and half passes around the annular space on the other side of the piston, while the remaining half is forced into the pipes, the area of the plunger, *a*, being half that of the piston, *b*. The large plunger and weight-box designated an accumulator is exhibited in Fig. 2.

a, cylinder with plunger; *b c*, loaded weight boxes; *d*, guide for ditto; *e*, pipe from pumping engine; *f*, pipe to hydraulic engines. The load upon the plunger is usually such as to give a pressure of from 300 to 500 lbs. per in., whilst the case is made sufficiently capacious to contain the largest quantity of water which can be drawn from it at once by the simultaneous action of all the hydraulic machines with which it is connected. Whenever, also, the charging pumps force more water into the ram case than passes directly from it, the loaded plunger rises and makes room in the cylinder for the surplus; but when, on the other hand, the supply from the charging pumps is less than the quantity required, the plunger, with its load, descends, and makes up the deficiency out of store. The weighted plunger is also made to serve as a regulator to the engine by operating on a weight, which is arranged so as to open or close the throtte-valve in the steam pipe. The hydraulic main is usually formed of wrought-iron pipes,

Fig. 2.



screwed into strong cast-iron flanges, the latter recessed so as to receive a ring of gutta-percha about $\frac{1}{4}$ in. diameter. In this way joints are rendered tight for very long distances, even although subjected to a continuous pressure of 500 lbs. to the in. Wrought-iron pipes may also be

readily bent when cold, so as to conform to the variable line of a level.

One of Darlington's pumping-engines for draining winzes consists simply of a cylinder, a ram, two side rods, a bar-valve, two regulating cocks, and cantilever. The weight of a 2-in. ram engine, 3-ft. stroke, is about 90 lbs. The speed at which the engine may be driven is 16 strokes per minute, and under a pressure of 500 lbs. per sq. in. it is capable of working a pump 8 in. diameter to 10 fathoms deep, or one of nearly 6 in. diameter 20 fathoms deep.

In the hydraulic main a constant pressure is maintained, and the momentum occasioned by the return of the stroke relieved by means of a lifting valve-lever and weight, similar to an ordinary safety-valve, but instead of a non-elastic connection between the lever and weight a spring is interposed, of sufficient elasticity to support the weight.

By this means the inertia of the weight is prevented from checking the sudden motion of the valve when acted on by the momentum transmitted through the water. Several advantages are offered by the accumulator system ; as, for instance, mountain streams may be arrested, and applied to drive a wheel, the power compounded and transferred over broken or hilly ground. The transfer main may be of very small diameter, and sufficiently light to be fixed in the roof of a level. Winding and pumping-engines, with cylinders of small diameters, will occupy but little room, and exert a large amount of power. The friction of the water is inconsiderable, when compared with the greatness of pressure which may be used. Little or no water need be wasted in effecting the transfer of power, since it can be returned to the charging-pumps, and continually circulated. Inconvenience and nuisance arising from the use of underground steam-engines may be avoided, and all the advantages derivable from their use secured. Machinery of this class need suffer no derangement from frost, since all risk in this respect may be avoided by placing the apparatus in buildings, or below the surface of the ground ; and in cases where this is impossible accidents can be prevented by letting out the water as soon as the machines are stopped.

EXPERIMENTS WITH A DECENTRING APPARATUS.

Abstract Translated from " Annales du Conservatoire."

In 1847, M. Beaudemoulin, *Ingénieur en Chef des Ponts et Chaussées*, made use of sand in decentring arches, applying its peculiar property when in its ordinary state of division of not conveying appreciable strains to its envelopes, even when under the direct action of considerable weight.

At first linen bags were successfully employed; afterwards iron cylinders filled with sand were used, upon which the pressure was distributed by means of a wooden piston. The first application of the cylinders was made in 1854, at Paris in the works of the Pont d' Austerlitz. Since that time they have been frequently employed. In 1864 and 1865, Marèchal made use of sand bags on a railroad at Brest and found them simple in use and economical.

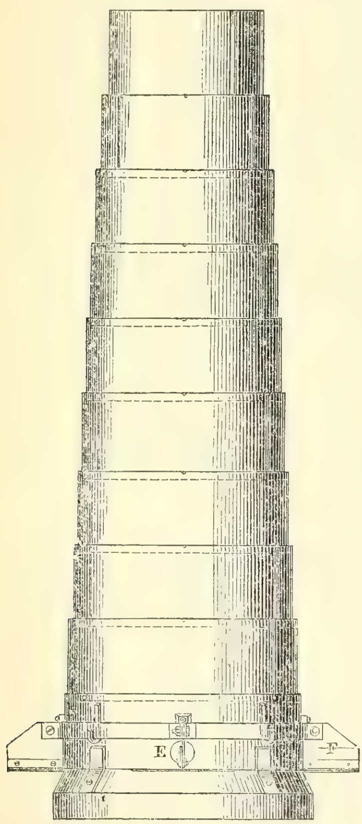
M. Beaudemoulin, seeing in 1855, at the Pont de l'Alma, the action of cylinders for decentring, noticed defects of which he gave an account in the " Annales des Ponts" (March 20). At the same time he observed important qualities in them which had been even considered as defects, and from these he deduced a new and important process, which he calls *differential*, which can be employed for as short periods as may be desired ; a great advantage in security and precision of working.

This method has become of general application. It was first employed at Paris in 1857, in the simultaneous decentring of the three arches of the Pont Saint-Michel, when 192 cylinders of sand placed at the points of support were made use of. With the old methods as many workmen would have been necessary; but in this case only a dozen were required, and the operation was successfully completed in two hours.

In 1866, M. Beaudemoulin exhibited at the Great Exposition a new apparatus, superior to that of the iron cylinders then employed, in regularity, precision, and

security of working. We have lately tried the action of this apparatus with two sets, one a model 0.161m. in diameter and 0.0015m. in thickness, the other a practical working apparatus, 0.314m. in diameter.

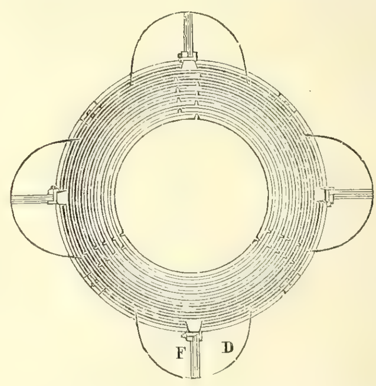
The model consists of 9 rings. The lower ring 0.155 m. in diameter and 0.056 m. in depth is fixed in a socket of wood, and is pierced with four holes 0.015 m. in diameter; below each of these a small horizontal piece called *bavette* is fixed.



This first ring is surrounded with a movable collar carrying four vertical fans disposed in such a manner that a slight displacement of the collar causes these fans to sweep off the cones of sand from the bavettes. This circle has play enough so as to slide easily. The first piece is also pierced near its upper edge with four holes about on a level, intended for the pins for holding the second ring while the apparatus is being set up. The other eight rings differ only in the absence of the orifices of discharge and of the collar. The dimensions are given in the following table:

Number of rings.	Height of ring.	Mean exterior diameter.	Mean interior diameter.	Height of pins above base.
	m.	m.	m.	m
1	0.056	0.161	0.155	0.050
2	0.054	0.151	0.148	0.055
3	0.054	0.145	0.142	0.044
4	0.053	0.139	0.136	0.048
5	0.054	0.132	0.129	0.048
6	0.054	0.126	0.123	0.048
7	0.054	0.120	0.117	0.048
8	0.054	0.115	0.112	0.048
9	0.054	0.109	0.106	0.048
Piston.	0.053	0.102	"	"

As many sets must be used in actual work, economy is desirable; the rings are therefore centred at the forge and not by lathe. This causes irregularities that would hinder sliding, if sufficient play



were not assured. To make a play of 2 to 4 mill. sufficient, it is necessary that each ring be furnished with three outside corresponding with three interior grooves on the internal surface of the next ring. In consequence of the failure by splitting along a groove of the 8th ring of a model, M. Beaudemoulin devised another plan. He pierces each of the rings with three large holes at equal distances; then setting the rings in pairs, he puts in each exterior hole small pins with round heads, adjusting them exactly to the inner rings, and then solders them to their place. By this means the play between the rings is kept constant, and friction is reduced as much as possible.

To fill the apparatus with sand, the first ring is filled to the level of the pins; after setting these and the ring which they support, the next ring is set in the same way. Care is taken not to allow sand to get between the rings. A piston of oak, 0.102 m. in diameter and 0.053 in height, is applied to the upper surface of the sand. The total height is 0.470 m.; when the rings are shut together this is reduced to 0.085 m.; giving a total play of 0.385 m.

It is an important fact, with reference to the charge of 12,504 kilog., that in the first experiments the four orifices of discharge were closed by four squares of paper held by a cotton thread passing over their centres and tied about the collar. Several experiments having shown that the paper was sufficient, it was afterwards employed, and the first cone of sand was allowed to form freely.

M. Beaudemoulin made use of four cones to insure the vertical position of the system. The total volume was 22.2 cubic centimeters. The mean exterior diameter of the column being 0.129 m., the mean descent for each *sweeping* is

$$h = \frac{0.000022\text{m.}^3}{0.01355\text{m.}^2} = 0\text{m}.00169,$$

which justifies the name *differential* given a process which causes the descent of a load by insensible fractions. It is possible to approximate an infinitesimal discharge by removing three fans so as to sweep off but one cone; then by setting the fans so as to sweep off but a small portion of the cones, which would immediately be replenished.

The descent is spontaneous under a charge of 0.25 m. to 0.26 m.; for a reduction of height, a hook must be employed to discharge the sand.

It is seen that, by the use of a sufficient number of these apparatuses, a difficult decentring can be accomplished under the best conditions, with few workmen, even with but one, who should see to it that the several descents were uniform.

To test the model to the utmost, it was placed on the plate of a hydraulic press.

The results of the experiment of June 24, 1868, were as follows. The 8th ring split along a groove under the last charge:

Total height of apparatus.	Pressures shown by manometer.	Charges.
m.	m.	k.
0.450[1]	0 000	0.0
0 420	0 200	7004.0
0.410	0 300	10506.0
"	0.350	12257.0

The results of the experiment of Aug. 28, 1868, were as follows. Under the last charge the upper ring parted:

m.	m.	k.
0.494	0.00	0 00
0.490	2 00	700.40
0 485	6 50	2276 00
0 480	12.00	4202.00
0.475	19.00	6654.00
0.470	24.00	8405.00
Rupture.	30.00	10506.00

It follows that the apparatus resisted a minimum pressure of 10.500 kil. They were subjected to pressure until one of the rings broke, and yet the sand did not escape. The four small squares of paper which closed the orifices, held by a fine thread, were not moved by these charges.

This is a remarkable fact, from which Beaudemoulin concludes that the lateral pressure of the sand is nothing, or nearly nothing, in that portion which is distant 20 centimeters below the piston. Putting R for the co-efficient of rupture, the formula for the resistance of cylindrical tubes of thickness e and interior diameter d is

$$2\,e\,\mathrm{R} = pd.$$

This gives for the pressure per square metre

$$p = \frac{2\,\varepsilon\,\mathrm{R}}{d} = \frac{\times 9.000027 \times 40{,}000.000}{0.112}\ 9642.8\ \text{kil.}$$

The charge on the base of the upper ring being 10.500 kil., is $\mathrm{P} = \frac{10.500}{0.009847}$ per square metre, giving between $p \times \mathrm{P} = 1066300$ an approximate ratio

$$\frac{p}{\mathrm{P}} = \frac{9642.8}{1066300} = 0\ 00904.$$

Hence the lateral pressure is not more than one 110th of the pressure at the top. M. Beaudemoulin thinks that this lateral pressure is due to imperfect mounting of the apparatus; that if it were set exactly vertical and were filled with perfectly dry sand uniformly distributed, there would be no lateral pressure whatever.

Apparatus 0.314*m. in diameter.*—This is of dimensions sufficient for actual decenterings; the results of experiments will therefore be of greater interest to engineers. The number of rings is three; the thickness of the cylinder is more than double that of the model.

	Number of rings.	Kind of sand.	Descent of piston.	Maximum pressure.
	m.	m.	m.	m.
1	0 11	0.306	0.10	0.0040
2	0.11	0.295	0.10	0.0025
3	0 11	0 282	0 10	0.0025

The total height of the mounted apparatus is 0.47m. reducing to 0.16m. when all the sand is discharged. It had done service under a pressure of 300 kil.; exment showed that it could resist a greater pressure. We tabulate the principal experiments.

Number of experiments.	Kind of sand.	Descent of piston.	Maximum pressure.
I.	River sand........	0m.015	17510k.
II.	Do., ...	"	23113
III.	Do., ...	"	19261
IV.	Do., ...	"	19261
V.	River sand sifted...	"	"
VI.	The same sand.....	"	26265

These experiments show that a charge of 26,000 kil. does not put an undue strain upon the cylinders, and that the rings of plate iron, which, with the exception of the lower, have a thickness of 0.0025m., reduced to 0.001m. in the grooves, suffered no appreciable deformation. Each of these experiments furnished special results, which we will state.

(1.) The apparatus was placed on the plate of a hydraulic press with its frame removed, the piston being held by a stone dressed to the proper level and projecting from a wall which could not be disturbed by the pressure. The sand was dried and sifted. At the close of the experiment it was found that a collar of sand 0.003 m. high had formed between the piston and the inner surface of the first ring. It could not be ascertained whether the piston had only pressed down the sand directly below leaving this ring behind it, or whether it had been partly pushed up by the pressure.

In this as in all the other experiments the orifices of discharge were left open, and the little cones which had formed before them outside while the cylinders were filling, had sufficed to prevent the sand from escaping even under the greatest pressure.

(2.) The same formation of a ring. Charge of 23113 kil.

(3.) Especially designed to show its efficacy in decentring After reaching a pressure of 19261 kil. the cones of sand were swept off by the sweeping collar. The sand always escaped with great regularity, and at the end of the operation (limited by the play of the piston) the piston had descended in the third ring 0.073; this third ring had sunk in the second 0.089m., and this in the first 0.045m.; a total descent of 0.207 m.

(4.) Under a charge of 19261 kil. the piston descended 0.010m. before discharge. The sand escaped easily when the cones had been swept off; but the discharge ceased as soon as pressure was taken off. It was found upon examination that there was cohesion in the sand, increasing from the centre outward.

(5.) River sand was carefully dried and sifted twice to get rid of dust and smaller particles. After discharge the sand was again sifted, and it was found that there were 18 litres of coarse sand, 1.5 litre of fine, partly reduced to dust; that is, pulverization was produced in the ratio $\frac{1.5}{19.5}$. This sand left the fingers white after the pressure, but not before.

(6.) The pressure was put on to 26265 kil., and maintained for 15 min. at 24515 kil. After discharge it was observed that the white powder due to pulverization was uniformly distributed throughout the mass. Sifting gave 17 litres coarse sand, 4 litres fine. Before discharge a plate of metal was vertically inserted in the sand, and it was found at all points so agglutinated as to sustain itself without talus.

THE Belgians are entitled to the credit of having built the first high-blast furnaces. They introduced them into England in the middle of the 15th century; and in 1612 Sturtevant obtained a patent in England for smelting iron with bituminous coal; previously charcoal was used, and only 2 or 3 tons of iron could be made per day with one furnace.

METALLINE.

We extract from the columns of "Engineering" the following patent specification, which presents in full the theory upon which the manufacture of metalline is founded:

This invention of "Improvements in the treatment or preparation of various natural substances so as to render them applicable for use in journal boxes and other parts of machinery or other articles whose services are intended to be subjected to friction," relates to a new and useful process for treating certain natural substances by which they are produced in such conditions that while they possess that degree of solidity which is necessary to bear (without material change of form) the pressure ordinarily applied to journal boxes and other articles whose surfaces are intended to be subjected to friction in machinery and elsewhere in the arts, at the same time so little friction will be actually caused and so little heat thereby developed in the practical use of such articles made of them that all necessity for the application of oil or any other lubricant to their surfaces will be entirely obviated.

The description will be more readily and clearly understood by first stating certain familiar elementary facts and principles involved in the phenomena of friction, and the development of heat thereby.

All matter is supposed to exist in its ultimate form as indivisible atoms held together by a force called the attraction of cohesion, but nowhere are these atoms actually in contact with each other, such contact being prevented by an antagonizing force called repulsion, leaving vacant spaces or interstices between them. In proportion as these atoms in any aggregation of them are drawn more nearly in contact does the mass become solidified, or, in other words, just in that ratio is their tendency to maintain a fixed relative position, and is the difficulty increased of causing them to move around and upon each other. The more widely they are separated from each other the more plastic, yielding or fluid does the mass become, and the less is the force required to cause movement among the atoms; or, in other words, just in proportion to the nearness of the atoms to each other is the energy with which the two forces act, repulsion to resist a further approach, and cohesion to prevent separation, the combined action of the two being to hold the atoms fixedly at the point where these forces balance each other. But whatever may be the atomic condition in the respects named, however slightly or however rigidly the atoms may be held together in a fixed relative position, so long as they remain within the sphere of the action of the forces named, some expenditure of a counterforce is neccessary to cause movement among them, the amount in every case depending of course upon the energy with which cohesion and repulsion are acting. In some kinds and conditions of matter there is that peculiar action of cohesion and repulsion, as in most crystalline bodies, which causes the atoms to have so strong a tendency to maintain a fixed relative position, and to resist inter-atomic movement, that less force is required to detach them completely from each other than to effect a change of position among them. Such substances are brittle and unyielding; they refuse to submit to a change of form except by abrasion, or by being broken or crushed in pieces.

Cohesion and repulsion act only at insensible distances, but whenever any two atoms of matter approach within a certain distance they do invariably act, and a counterforce must be employed to disturb the atomic arrangement which they effect.

Adhesion is commonly understood to be that tendency which the atoms or particles of one mass of solid or semi-solid matter have to stick or adhere to those of another. It (in fact, however) only differs from cohesion in the condition under which it takes place, adhesion acting between the atoms of one mass, and those of another cohesion between those of the same mass. Cohesion and adhesion are therefore really the same force or property. The energy with which adhesion in any case acts is (as is true of cohesion) in proportion to the nearness to which the atoms of the one surface are made to approach those of any other, and therefore it is only between masses that are (one or both) in some degree plastic or yielding that it takes place. But between all such substances it does manifest itself to a

greater or less extent, and therefore this property of matter plays a most important part in the phenomena of friction, and the heat thereby developed, as will presently appear. Heat is but a mode of motion, and all motion is caused by an expenditure of force ; hence it follows that there can be no expenditure of force without the development of heat, and an amount of heat that is exactly the equivalent of the force expended. Heat in its manifestation among the atoms of matter acts to drive them asunder, thus diminishing cohesion, and tending to facilitate change of relative position among them, and determining their condition as to solidity and fluidity of their masses. But as the articles (for which the compositions made by the process are to be used) are used generally at the ordinary temperature of the atmosphere, it is not necessary here to take into consideration the molecular changes effected in matter by heat other than those occurring from that degree of heat developed by friction in the actual use of these articles ; but with reference to such heating it is important to bear in mind that most solid or semisolid substances are rendered more plastic by heat, and in proportion to the degree of heat present is the tendency to adhesion between the surfaces of two heated masses. In the light of these familiar principles it is not difficult to apprehend the philosophy of friction and its resulting heat. It is obvious from its atomic constitution that no mass of matter can be made to present a surface that is an absolute plane ; even if it were possible to level down all asperities formed of aggregates of atoms there would still be atomic prominences and depressions. But practically it is impossible to polish away entirely all inequalities other than those resulting from atomic structure. Now when two surfaces that are not absolute planes are rubbed together as nearly in contact as possible, or rigidly held from receding from each other, whatever inequalities or prominences there are must present obstacles to free movement. They will clash together, impinge against each other, and when they thus come into collision the motion of the surfaces must be arrested, or sufficient force must be applied either to break off and detach the colliding atoms or aggregate of atoms from the masses to which they cohere, or to change their position and depress them so far that they can pass each other. If they become detached they will still continue to be obstructions to the free motion of the surfaces, cutting into and roughening them, augmenting the difficulty of their movement, and calling for increased expenditure of force, which results of course in an increased development of heat. If the mass is so far plastic or yielding that no detachment or abrasion takes place, the atoms must be made to change their relative position ; then an undulatory motion may occur, the depression of those most prominent causing the elevation of others in their vicinity, they to be in turn depressed, and so on continually while the rubbing of the surfaces together is continued. But this molecular undulation demands the expenditure of force to produce it just in proportion to the resistance which cohesion among the atoms opposes to it, and of course the equivalent of this force will appear as heat. Still another obstacle to the free movement of the surfaces upon each other exists, namely, adhesion, which plays a most important part in friction. If any surface is brought so nearly to a plane that a considerable number of the atoms composing it are caused to approach so nearly in contact with those of another (that is, being rubbed upon it) as to bring them within the sphere of cohesive attraction, the two surfaces have a tendency to adhere together. The expenditure of force is then required to prevent them from doing so, and heat will of course result from such expenditure of force.

We have now before us what is believed to be the true philosophy of friction and heat resulting from the rubbing of one mass of matter upon another, and it discloses a most important fact, a fact which is the key to the new process. It is this, that always and everywhere friction is the resistance which the cohesion and repulsion, one or both, of the atoms of the bodies whose surfaces are being rubbed together (which, for convenience, I will call elemental force) offers in some way to the force expended to cause the movement of the surfaces (which, for like convenience, I will term mechanical force), and the heat developed by the friction is the equivalent in another form of the mechanical force thus expended.

It is not, of course, difficult to find con-

ditions in nature or to produce them by art in which these forces, one or both, act with little energy, and where there is consequently little friction. Most of the fluids present them, but these are not the only conditions demanded in substances that are to be used for journal boxes and other similar articles. There is demanded a certain degree of solidity (required to prevent change of form under the pressure to which these articles are to be subjected), and it is difficult to find or produce a substance having the last-named property which is at the same time of such a nature that so little friction is caused by rubbing its surface that when employing it for the purpose of journal boxes in machinery the use of a lubricant can be dispensed with. In fact, nature, so far as is known, has not given us such a substance, and it has not heretofore been thought possible to produce it by art. I have discovered it is, however, possible to do so, and by the improved process such a substance, or rather a series of substances, is produced as by experiment and trial has been now abundantly demonstrated. To the substances so produced is given the name of "metalline."

In describing the mode of treating a great range of materials so as to produce the important result stated above, I shall assume that this description is given to those who are acquainted with the natural properties belonging to the elements and substances treated, whether simple or compound, and with what our present science teaches of their possible changes and modifications under the action of chemical laws and mechanical forces.

The properties requisite in a substance to render it suitable for journal boxes and other working parts of machinery, and which can be used practically without a lubricant, may be stated to be the following:

First.—That degree of solidity or coherence necessary to prevent change of form to any considerable degree of the article made of it by the pressure to which it is to be subject in use.

Second.—Such a degree of plasticity or facility of movement of the atoms or particles over and upon each other that the expenditure of force sufficient to cause so much of the movement as results from such rubbing practically in machinery shall not develop heat more rapidly than it can be conducted away in the atmosphere at ordinary temperatures.

Third.—Just such a degree of non-plasticity or fixedness of the relative position of its atoms or particles, and a repulsive tendency between its atoms and those of the journal-box or other opposing surface, that adhesion between its surface and that of the body rubbed upon it in practical use will not take place to such an extent that the heat caused by overcoming it will not be radiated away as rapidly as it is developed.

Fourth.—Such an adjustment or balance of the three preceding conditions that little or no abrasion or wear, *i. e.*, change of quantity of the journal-box or shaft, shall take place.

To combine these conditions in one and the same body is the object to be secured. To secure it, I take some natural substance, which, if it have sufficient solidity for the purpose, will invariably be found to have too much coherence; that is, it will have either too rigid and unyielding an atomic structure, so as to crumble and wear into powder by rubbing, or it will be non-coherent to such a degree, that it will exist as a sand or powder, or it will be too adhesive, so as to stick or cling to the body being rubbed upon it to such a degree as to cause too much friction. Its natural conditions in this respect must be changed or modified by first destroying its natural coherence (if it exists in masses which cannot be controlled), and then establishing an artificial union among its particles which can be controlled. To this end the atoms are sundered as far as possible from each other by solution and precipitation by heat, by abrasion, or by trituration, or by some other suitable method, if the material used requires this treatment. The nature of the substance in hand will determine the particular method employed, the object being to break up and destroy its natural coherence. If the substance is not one whose too great original coherence was due to the presence of some element the removal of which merely will effect the desired modification, or one whose molecular structure it is only necessary to change by heat, electricity, pressure, or some other temporarily acting modifying agent. I then proceed to intimately mix or combine with it another substance, one that has naturally comparatively but little

coherence, and which is susceptible of intimately commingling with its particles, and surrounding, or infiltrating, or interposing itself between them, so as to prevent by any means their consolidation into their original natural state. Then the compound thus prepared is to be subjected to just that degree of pressure requisite to impart to it the necessary solidity to prevent crumbling under friction, or to any considerable extent changing form under pressure when put to use as a journal-box. Pressure at this stage is important also because it tends to produce a more intimate commingling, a more equal distribution, and a finer interadjustment of the particles of the several elements of the compound. This pressure may be applied in a suitable mould to give the body the desired solidity, and most conveniently by an hydraulic press.

If the substance in hand is embraced in the class of compounds included in the exception first above named, a knowledge of the nature of its elements will readily disclose that one to which is due its too great adhesiveness. This adhesive element is then to be removed in whole or in part, or modified, as may be necessary, by means properly adapted to do so, which the expert will know how to select and apply, and just how much of the element must be removed to secure the conditions required as above set forth will, of course, depend upon circumstances; but, knowing the nature of the substance under treatment, and the precise object aimed at, as hereinbefore defined, the expert here will have no more difficulty in successfully performing this needed manipulation of the substance, than does the expert in machinery in calculating and adapting the different parts of a machine to secure a given result. When the substance has undergone the change indicated, it is then to be subjected to pressure as before described.

If the substance belongs to the class included in the second of the above-named exceptions, then the same knowledge of its nature above supposed to be possessed by the expert will enable him to apply the requisite modifying agent successfully to effect the object aimed at.

If the substance employed be a brittle or friable one, and is already in a powdered or disintegrated state, then is to be united with it another capable of becoming intimately disseminated among the particles of the powder and in some measure adherent to them, and having sufficient coherency among its own atoms to be susceptible of becoming aggregated with such particles into a mass by pressure, which, while it has sufficient solidity to answer for a journal-box or journal-box lining, at the same time has just that degree of facility of movement among its atoms and particles hereinbefore stated as requisite. The aggregating substance may be one which alone has too much coherence and plasticity to itself make a journal-box that can be used without a lubricant, but which in its combination with the powdered material will have its coherence reduced and its plasticity modified so as to produce the required conditions.

Now having stated the principles and method to proceed upon in the process, I will give a number of illustrations of its use. [The inventor here gives 15 examples, of which, however, we only quote the following:]

Example No. 1.—In this example take of iron 50 parts in such a state of division that it will pass through a sieve with at least 10,000 holes to the inch. It is well to protect the surface of the particles of the powdered iron from oxidation before it is compounded with the tin by covering them with any oily substance. Half of one per cent. of paraffine intimately mixed with the iron dust in a heated mill will prevent oxidation of the particles for months. Then take of tin 50 parts, which it is preferred to have as finely divided as the iron, but its high pulverization is not so necessary as that of the iron for obvious reasons. These metals are then intimately mixed by grinding or otherwise, and the mixture subjected (in steel or other suitable moulds) to pressure to give it the required solidity, say about 60 tons per superficial inch. The required consolidation will be determined by the use to which the resultant "metalline" is to be applied. The proportions given will be found to be those most generally serviceable, but they may be varied to meet the various conditions under which the metalline is to be used.

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Example No. 15.—In this example the breaking to a certain degree of the natural cohesion of a metal is effected by

heat alone, and while the metal is held in a state of molecular disintegration by a continued application of the proper degree of heat, another substance having slight cohesion among its own particles is introduced among the atoms of the metal, which interposes a barrier to the restoration of the natural cohesion of the metal when the heat is withdrawn. To this end take a metal which between its solid and melted state is susceptible of a semi-fluid condition, in which it is found to be plastic, easily moulded, somewhat granular, and only feebly coherent. Such a metal is the common plumbers' solder. When this metal is heated, and just before it reaches the melting point, mould or stir into it a small quantity of carbon graphite (blacklead), or some equivalent substance; 3 to 20 parts of the carbon graphite with 80 to 97 parts of the solder will be found to be a serviceable proportion. The two should be intimately incorporated together, the heat of the metal being meantime maintained at the proper point, and before it is so far cooled as to become solidified the mass should be subjected to pressure in moulds to give it such shape as may be required for use. When a metal or alloy has thus been incorporated with the graphite or any equivalent substance for the purpose here intended, it should not be thereafter melted, as the two will immediately separate on being completely fused. When a change of form is desired, raise the temperature to near the point of fusion, and then press the mass in moulds of the required shape. There are many substances that will be found to be the equivalents of the carbon graphites for the purposes just described, those which are susceptible of being reduced to fine and impalpable powders, for examples, many others of the graphites, the precipitated metallic oxides, etc. The graphites are sometimes used for convenience when not reduced to a very fine powder, and are valuable adjuncts in making metalline.

I may mention in a general summary among the articles that will be found serviceable in preventing the restoration of the natural cohesion of metals or alloys after such cohesion has been broken up as described, the graphites, paraffine, beeswax, spermaceti, and caoutchouc. Gutta-percha, gum ballatta, oleaginous substances may be used, as they operate to coat and envelop the particles of the metals, thus preventing cohesion between such particles, and also between the journal box made of metalline and the journal. Gum resins, such as shellac copal, are often found useful in imparting additional cohesiveness where the cohesion is too feeble. Nearly 5,000 varieties of metalline have beenmade, and it is obvious that, drawing our resources from the vegetable, the animal, and the mineral kingdoms, the entire realm of nature (and examples of each have been given), many millions of varieties of metalline may be produced.

In each of the examples now specified there is a large class of substances that may be substituted for the principal elements named, and which when substituted for them respectively will be found to be equivalents. Of course all equivalents of the several substances named in the several compositions respectively are claimed.

What I claim and desire to secure by Letters Patent is:

First.—The process herein set forth of selecting, treating, compounding, and consolidating certain substances, by which are produced new compositions of matter (denominated by the inventor "metalline") designed for the purpose of journal boxes and other parts of machinery, and other articles whose surfaces in use are subjected to friction, and which substances possess such properties and conditions that in the practical use in machinery and elsewhere in the arts of such articles made of it, so little friction is actually caused and so little heat thereby developed, that all necessity for the application of oil or any other lubricant is entirely obviated, as herein set forth.

Second.—I claim each of the several compositions of matter hereinbefore described when respectively composed of the substances specified or their respective equivalents, and compounded and consolidated in the manner described, or ang other manner by which an equivalent effect is obtained for the purposes named.

It is said that there is a prospect of the new rolling mill at Portsmouth, Ohio, being re-organized to commence work again. It is said that the mill will probably prepare to make railroad iron.

IRON AND STEEL NOTES.

It appears that the Styrum (German) Metallurgical Company produced last year 19,149 tons of iron in bars and rails, 6,906 tons of plates, and 949 tons of pieces of cast-iron, making a total of 27,003 tons, against 24,616 tons in 1868. A very large iron bridge is about to be thrown across the Neva, at St. Petersburg. It will be about 1,100 ft. in length, and will probably rest on twelve or fourteen piers. The weight of the iron-work involved in the construction of the bridge is estimated at upwards of 6,000 tons.

The war checks and even interrupts in some localities the exportation of coal from Belgium, and this sad state of things will probably last some time. On the other hand, the exportation of Ruhr coal being again permitted by Prussia, Holland is now sending Belgium fewer orders for coal. The situation, then, is calculated to inspire some uneasiness. Some of the Belgian blast-furnaces and rolling-mills may possibly also restrict their production, and this would, of course, involve additional depression in the Belgian coal trade. Meanwhile, as the extraction of coal in Belgium has been somewhat moderate of late, prices maintain themselves tolerably well. The Belgian Government has not ratified an "adjudication" which took place in July at Brussels, and which comprised, *inter alia*, contracts for about 5,000 tons of Bessemer steel rails. The contracts were secured provisionally by M. Adhemar Le Roy, representing Messrs. C. Cammell and Co. (Limited), of Sheffield, and by Messrs. Tiden, Nordenfelt and Co., of London. The Belgian Government has now declined to ratify the contracts, but will let similar contracts instead to some Belgian firm. The Cockerill Company, at Seraing, is the only Belgian establishment which has appliances for the production of Bessemer steel, and will, consequently, in all probability receive an order for the rails in question.

The condition of the French iron trade has not changed very much during the last few days, but a general feeling of depression and uneasiness prevails. The forgemasters of the Champagne group have not slackened their production, and it is stated that they have decided to make every possible effort to avoid extinguishing their furnaces. In the Moselle district the Ars and Hayange furnaces have continued their operations, so far as it has been practicable to do so, having regard to the relatively limited number of men whom the war levies have spared for industrial pursuits. At present the blast-furnaces of this group have not been blown out. The advices received from the Longwy district are tolerably good, the works having a fair number of orders on hand; this group has benefited from its situation, and the intelligent measures taken in regard to it by the Great Luxembourg Railway Company, which has endeavored to reduce to a minimum the inconveniences resulting from the heavy military traffic which has been passing over the local railways. White coke-made refining pig is quoted in the Moselle at £2 18s. 4d. per ton; speckled pig, £3 0s. 10d. per ton; grey-refining pig, £3 3s. 4d. per ton; casting pig, No. 1, £4 4s. per ton; ditto, No. 2, £4 per ton; ditto, No. 3, £3 16s. 8d. per ton; ditto, No. 4, £3 13s. 4d per ton; ditto, No. 5, £3 10s. 6d. per ton; charcoal-made refining pig, £5 8s. per ton; rolled coke-made iron, £8 4s. to £8 8s. per ton; cast-iron pipes, £6 16s. per ton; solid columns, £5 16s. per ton; hollow columns, £3 16s. per ton, The sale is to be attempted this month of the Blanc-Murger forges, in the valley of the Semouse (Vosges); the sale is proposed to be proceeded with at Remiremont, on Sept. 8. The municipal authorities of Rochefort have been authorized to borrow £44,000 to provide for an improved water supply at that town. The supply proposed is to be at the rate of about 25 gallons daily for each inhabitant of the town. The Compagnie des Chantiers et Ateliers de l'Ocean has established in the Mazeline Works at Havre a special establishment for the manufacture of locomotives and tenders. Besides having various orders on foreign account, the Company is now engaged on a number of locomotives for the Western of France Railway Company. Axles of great durability are being introduced into these engines, on a principle patented by the Western of France Railway Company. An engine with these axles has been running upon the Western of France Railway for the last five years, and has run upwards of 300,000 miles without its axles exhibiting any signs of decay.

British Iron Trade.—The iron trade of this country need not be at all alarmed at the warlike attitude assumed by two of the most important nations of Europe. Instead of having them for customers of late years we have had them as rivals, and they have been sharp and active ones too. They are now about to enter upon a struggle, of which no man can say when it may end, and which will require all the resources of the two nations, and all the youngest and best blood of their populations. From the arts of peace they will now have to turn to the art of war, and their necessity will be England's opportunity. The withdrawal of a large part of the populations from the iron trades of France and Prussia will naturally throw a good deal of work into this country. We know very well what the effect would be upon the iron trade of Great Britain, if we had to withdraw our iron-workers from the mills and furnaces of the iron districts and turn them into soldiers or sailors. We should then be forced to fall back upon the resources of these very continental nations who have for years past been our active rivals, and then our necessity would be their opportunity. All we have to do is to keep out of the quarrel ourselves, and let France and Prussia do the fighting whilst we do their trade. And, as the "Economist" well puts it, "the gain to English trade will be considerable in various ways. The use of capital on a large scale which was spreading of late so rapidly through Northern Europe, and was daily bringing more and more competitors into profitable markets where English manufactures had been used to certain superiority, is for the present arrested. We shall now once more have an indisputable pre-eminence in many trades, such as we have not had for years, and such as it was not likely we should again see. A vicious speculation in the raw material of our principal manufacturing industry has been broken up. A great trade will set in in instruments of war, which, in spite of declarations of neutrality, both belligerents will wish to buy here, and which we shall in fact sell to both of them. All the carrying trade will be in our hands. English vessels will be able to keep the sea, while both French and German vessels will be a prey to hostile cruisers. And we shall have an augmented commission trade too." Therefore, instead of the

iron trade being threatened with a serious check, as some newspaper writers assert, a renewed prosperity is in store for it. The reports which we have received from the various iron districts, show a continued briskness in all departments; and as regards prices they are still firm. The shipments of iron, on foreign account, from the ports of Middlesbro', Cardiff, and Liverpool, keep well up, and the home demand for iron for railway and engineering purposes is much stronger. With regard to the labor question, we do not think there will be any disturbance in North or South Staffordshire, and the present agitation seems to be waxing weaker every day, and will soon melt away altogether.—*Mechanics' Magazine.*

A Model Iron Works. The Works of Sir John Cockerill and Co., Belgium.—We have in a previous Journal published a brief account of these important works; we are now, however, in a position to give a full description with most minute particulars of this model establishment of the world. The statistics are translated from a statement handed to us by M. Pastor, one of the head managers, and the gentleman who acted as guide to the party of mining and mechanical engineers who lately visited Belgium. We have not thought it necessary to convert the French moneys, weights, and measures into English, as it would only cause a complication of decimals if done correctly, and we are quite sure our readers are sufficiently conversant with them to thoroughly understand the particulars.

John Cockerell, who, by the by, was an Englishman, established the works at Seraing, in 1817. He started in a small machine shop, in a very small way; but the works have gradually grown till they now occupy the whole of the extensive gardens of the ancient bishops of Liege, the present offices have been the fine old palace, so that it makes a noble front for the works, which are situated on the banks of the Meuse. This Company carry out the whole operations, from the raising of the coal and minerals to the turning out of the finest engines, bridges, iron-clad ships, etc. The general director is M. Sadoine. The area covered by the works is 90 hectares, one-eighth of which is entirely taken up by buildings. The number of persons employed in 1867 was 7,277. They pay annually for salaries 6,660,000 francs, and employ 156 steam-engines, of the collective nominal horse power of 2,843. The yearly amount of work constructed is valued at 25,000,000 francs, and the quantity of fuel consumed is computed at 220,000,000 kilogrammes. The collieries employ 2,157 persons, and steam-engines of 628-horse power. There are four separate places of extraction, and eight pits or shafts used for raising the coal, ventilation, and the descent and ascent of the work people by means of the fahrkunst, or man-engine. From these pits are raised 260,000,000 kilogrammes of coal. They employ 195 men and women to convert coal into coke, and steam-engines of 87-horse power. There are five lots of coke ovens (of two classes), six stamps or pounders, two washing machines, and eight steam drying furnaces, for preparing the coal before it goes to the ovens; 80,000,000 kilogrammes of coke are produced annually.

In the mines are employed 875 operatives, and steam-engines of 224-horse power. There are 30 places where the mines are extracted, in the provinces of Liege, Namur, and Luxembourg, and the total amount produced yearly is 146,000,000 kilogrammes. There are five blast-furnaces, with steam-engines of 548-horse power, and employing 288 persons. The blast-engines are very powerful, and produce a pressure of blast equal to $3\frac{1}{4}$ lbs. to the sq. in. The boilers and hot-air furnaces are heated by the waste gases. The annual produce of iron amounts to 50,000,000 kilogrammes. In the foundries 256 work-people are engaged, and the engines are of 32-horse power. There 8 cupolas, and 800,000 kilogrammes of moulding boxes. They have two separate buildings for core making and drying; 5,000,000 kilogrammes is the weight of castings turned out annually. In the iron-works—that is, the mills and forges—985 operatives are engaged. The steam-engines are of 532-horse power. There are 68 reverberatory furnaces, 13 rolling mills, and 5 hammers. Plates and sheets, merchant iron, and specialties are produced yearly to the total weight of 10,000,000 kilogrammes, and rails to the amount of 25,000,000 kilogrammes, making in all 35,000,000 kilogrammes. The steel works employ 191 work-people, and steam-engines of 520-horse power. There are two large Bessemer converters, 5 ordinary furnaces, 24 casting furnaces, 15 reverberatory furnaces 7 hammers from $\frac{1}{2}$ to 15 tons, one rolling mill of very large dimensions, and two rolling mills for railway wheel tyres, fitted with all necessary hydraulic apparatus. The annual production amounts to 7,500,000 kilogrammes of wrought and cast-steel, steel rails, tyres in steel and iron, and steel castings for machinery.

In the iron forges, engine and machine shops, there are 1,184 persons employed, and engines of 224-horse power. There are 23 reverberatory furnaces, 13 steam hammers, 230 lathes, 18 slotting machines, 84 planing machines, 90 drilling machines, 5 machines for forging nuts and bolts, and 3 hydraulic presses. The quantity of engines and machines constructed annually amounts in weight to 7,000,000 kilogrammes. The boiler and bridge yards employ 573 persons, and engines of 42-horse power. There are 18 drililng machines, 35 punching machines, 7 sets of rollers, for bending plates, and 20 shearing, planing, multiple drilling, and riveting machines; 4,000,000 kilogrammes of steam boilers, bridges, etc., are made annually. In the Antwerp shipbuilding yard 319 persons are engaged. There is one steam-engine of 8-horse power, special docks for all classes of marine constructions, shipbuilding sheds of glass, rafts and boats, machines for masting, stocks, and launching cradles, both for sea-going vessels and river boats. The weight of marine constructions made nearly amounts to 2,000,000 kilogrammes. From 750 to 800 operatives are employed in the St. Petersburg yard, and it is furnished in every respect similarly to the Antwerp one. The annual productions weigh 1,500,000 kilogrammes. There are 111 managers and clerks belonging to the establishment. The area of the works is divided in the following manner: The Seraing works cover 72 hectares, the Antwerp yard $5\frac{1}{2}$ hectares, that of St. Petersburg $1\frac{1}{2}$ hectares, and their own mines 11 hectares. Independently of the above, they hold under Government for getting coal 195 hectares, and for getting mine 3,500 hectares.

They have constructed at the Seraing works 1,687 steam-engines of from 4 to 600-horse power for industrial applications, 975 locomotives of all sizes and systems, and 11,650 machines, forming complete works and parts of works, for raising and

reducing coal and minerals, the working of metals, for construction, sugar factories, the making of ice, paper making, weaving, bridges, suspension bridges, etc.

The yards of Antwerp and St. Petersburg have furnished for navigation 174 ships, river boats, pilot boats, floating lights, dredgers, transports, packets, floating docks for frigates of the largest size, and iron-plated monitors. The two armor-plated monitors with towers, propellers, and machines for towers, ventilators, gun carriages, centrifugal pumps, and accessories, supplied for Russia in 1864, having been ordered on June 18, 1863, were sent for finishing to St. Petersburg in October, 1863, and booked to the Imperial authorities, fully equipped and armed, after trial on June 13, 1864, having been commenced and completed ready for service in less than 12 months.

The works of Sir John Cockerill and Co. can furnish annually 50 locomotives of the first-class, 70 marine engines of from 4 to 1,000-horse power, 1,500 lots of mechanical constructions, 3,000,000 kilogrammes of bridges and like structures, 14 ships and boats, taking 5,000 tons of material, besides coal, coke, minerals, castings, wrought-iron, rails and steel in the quantities before mentioned. Every department is kept strictly apart, so that each one seems to belong to a separate proprietor.

THE declension of iron manufacture in Russia arises chiefly from deficiency of fuel, and the great distance of the mines from the centres of commerce and civilization. The iron industry in Russia owed its origin to Peter the Great, and, 150 years ago, vast mines were wrought and great works erected. The empire seems to produce every description of ore, and each in great variety. In the Altai and the Oural vast masses of magnetic ore are found. There are various other directions where magnetic ore is found in smaller deposits. Very fine ore for the purpose of steel manufacture is extracted in several districts. Ordinary ores are much more abundant, and are discovered over a wider area of country. In the centre of Russia red oxide is the prevailing yield. One great advantage is that a deep iron mine is not known in Russia; whenever the metal is found it is near the surface. It would be impossible to estimate the resources of this country in iron; probably it exceeds that of any other country in the world.

THE IRON TRADE OF FRANCE.—The accounts from Champagne are better than could be expected, considering the gravity of the events which are taking place in the department of the Haut-Marne. Some works are closed, it is true, but most of them continue in operation in spite of the occupation of the country by the enemy; all that is produced, however, remains in stock, except the small quantity wanted in the immediate neighborhood, for there are scarcely any means of transport, the railways being cut at certain points, and the navigation of the canals being irregular in the extreme. Coal has not yet run out for the furnaces, and forges had taken the precaution to lay in large stocks. But the provision cannot be inexhaustible, so that unless supplies arrive work must necessarily come to a stand-still before long. Commercial orders there are none, and quotations are nominal. In the Moselle the situation is much the same, and prices stand without alteration. There is not much doing in Paris, and the price of merchant iron has fallen fifty centimes; flooring iron is now quoted at 21f. for small quantities, main pieces are worth 27f. to 28f. On account of the want of workmen the orders are merely for the completion of works in hand; nothing new, of course, is undertaken at such a moment as this. The difficulties which exist elsewhere cause great activity in the basin of the Loire; all the works at Firminy, St. Etienne, St. Chamond, Aissailly, and Rive de Gier, are putting on all the steam available. The guards are doubled where any workmen are engaged. The house of Petin-Gaudet is still hard at work for the Government, producing all the cannon, rifles, armor plates, and balls that it can possibly turn out. MM. Manel Freres, of the Rive de Gier, are making thick plate shields for the mitrailleuse, and have just sent off forty of these shields. MM. Jacob Heltzer and Co., of Mineux and Pont Salomey, are turning out small arms and bayonets as fast as possible.

ANNEALING METALS.—According to the invention of Mr. J. M. Bottum, of England, an annealing pot of any common or suitable form is employed, within which the metal to be annealed may be packed in charcoal or other material, and the whole introduced into the furnace for heating in the customary manner. When the heating is completed the pot is removed from the furnace and placed in the improved cooling chamber, which is then closed air-tight until the gradual cooling of the metal within the annealing pot is finished. The annealing pot during this process is preferably supported at a considerable distance from the external walls of the chamber, and the cooling chamber itself is preferably supported in such a manner as to lessen or avoid any unequal conduction of heat from its various parts.—*Mining Journal.*

CASTING OF AN ENORMOUS STEEL INGOT.—That Sheffield owes much of its prosperity to the development of the iron and steel trade is generally acknowledged, and it may be fairly claimed that to the enterprise of Messrs. Thomas Firth and Sons, of the Norfolk Works, no inconsiderable share of the honor is due. It was considered a great achievement some time ago when castings were required for the Whitworth gun to produce them weighing 15 cwts., but so rapid has been the strides in scientific and mechanical appliances that now they are regularly cast of at least ten times that weight. On Tuesday preparations which had been in progress some days were completed for producing by far the largest crucible steel casting which had ever been attempted, and the arrangements were so complete as to secure the most perfect success. The casting is designed for the beam of the screw steamship Munster, belonging to the City of Dublin Steam Packet Company. The mould in which the ingot was cast was upwards of 14 ft. in length and 3 ft. in diameter, and was fixed in the middle of the principal melting furnace. About 300 men were in attendance when the interesting operations began, which were under the personal superintendence of Mr. Mark Firth. Almost military precision was observed in bringing from the distant parts of the works the crucibles containing molten steel ready to be poured into the mould. This was fixed in a central position, and close at hand were 150 "holes," with tributaries from many other parts

of the premises, and we believe that altogether there were upwards of 270 in operation. Some idea may be gathered of the completeness of the arrangements when we say that in about half an hour the contents of no less than 544 crucibles of 64 lbs. each was poured into the capacious mould, making a total of 34,816 lbs., the teeming being done by eight men. There is no doubt that is the largest that has ever been produced. We believe that the ponderous casting, which weighs 15 tons 3 qrs. 12 lbs., will not be cool enough for removal in less than four or five days.

To Unite Steel.—It is proposed by J. Absterdam to unite cast steel or Bessemer steel or case-hardened wrought iron, either by pouring the molten cast or Bessemer steel against plates or slabs of blistered steel or case-hardened wrought-iron, or he heats the bar of cast or Bessemer steel to a yellow heat, and the bar of cement, steel, or case-hardened wrought-iron to a welding heat, and places them one on top of the other under a suitable press capable of exerting a pressure over the entire surface of the bars, and by this pressure the two metals are firmly united.

RAILWAY NOTES.

Self-Acting Coupling for Carriages.—Among the many persons who have turned their attention to the prevention of accidents through shunting and coupling railway wagons, etc., is Mr. James Turnbull, a legal gentleman in Edinburgh, secretary to the Berwickshire Railway Company, who has patented and tested by experiment a self-acting coupling for railway vehicles. Mr. Turnbull's invention consists of a horizontal arm projecting in front of the hook at present attached to the draw-bar of carriages, and hinged to the bar at the breast or buffer beam of the carriage. This arm is retained in the horizontal position by means of a weighted inner-arm, and in uncoupling is moved downwards by means of a lever carried to the outer side of the wagon. In shape the new coupling may be described as like a shoe, with a slot in the sole, into which the hook of the coupling—which represents the front upper of the shoe—slides when the wagons are brought together. On two wagons being run together, the action of coupling is performed without manual assistance. The elongated points of the shoe-shaped hook, formed of hardened steel, come together, and one passes beneath the other till the slot is reached, when the weighted inner-arm brings the under hook up to the horizontal position, and the fastening is accomplished. In the case of two wagons coming together exactly level, the depression of one of the arms is provided for by the hinge on which they move being made elliptical and sloping upwards, by which means the point of the arm is forced down by contact.

The merits claimed for this invention are various. In view of the great accident at Abergele, it may be said that had the runaway wagons been fitted with this coupling they would have been attached and caught, instead of being driven off, and thus the accident would have been prevented. It is obvious that with a self-acting coupling much time, as well as many accidents, would be saved in making up trains at the depot. By the provision of a side-lever to depress the hooked arm this invention also aims at abolishing the dangerous mode of uncoupling which the existing apparatus renders necessary. Another merit claimed by Mr. Turnbull is the saving in wear and tear by reducing the distance between vehicles not supplied with spring buffers. With the new coupling the distance would not exceed two or three inches, sufficient to enable the wagons to round a curve, and saving a great deal of damage to the permanent way at present caused by excessive oscillation, and to the plant by the shocks and concussions to which it is now exposed. The goods carried would also save damage caused to them by the shaking and bumping caused by the present loose system of fastening ordinary wagons. By retaining the present hook and chain the invention is capable of being gradually introduced into new and renewed stock, and could be worked along with old plant until the adoption of the new system became general.

We have in the above remarks given expression to the intentions and expectations of the ingenious inventor, but of course the plan still waits the proof of experience and the test of economy. So far as experiments have been conducted, by means of wagons thrown together at various rates of speed, we understand the invention has worked well, and the prevention of going within the buffers to uncouple has also been shown to be advantageous. Certainly an invention which offers to save life and limb, to reduce expenditure both of time and money in working, and to lower the wear and tear of line and plant, deserves the attention of the railway world. The difficulties in the way of adopting an entirely new fitting to the railway plant of the kingdom are great, but we believe that were practical men convinced that the proper remedy had been found for what is an admitted defect there would be little time lost in procuring its universal adoption.—*Railway News.*

The Euphrates Valley Railway.—The "Madras Athenæum," referring to the proposed scheme of Mr. Andrew for constructing the Euphrates Valley line, and the improved prospects which it now offers, says:—"We see already the kind of traffic which will find its way through the Suez Canal. That canal is chiefly a rival to the old Cape route, besides developing a traffic peculiarly its own with the coast of Arabia and the ports of the Mediterranean and the Bosphorus. It is not as a route for mails, nor yet for passengers, that the Suez Canal is to succeed, but as a route for heavy goods. The routes by the Euphrates and by the Suez Canal would not be rivals, but auxiliaries, just as were the old Cape and overland routes. And if France has had cosmopolitan spirit enough to construct the one, surely England will not lag behind and neglect the other, the less expensive, the more certainly remunerative, the shorter and pleasanter road. The Suez Canal was, to all but genius itself, a fearful speculation. The Euphrates Valley Railway is a most promising work. It is simply a missing link in a vastly improved and economical chain of communications. It is not such a missing link as was the Suez Canal, which leads ships through a desert, but one which connects markets together more closely, virtually opens out new ones, and furnishes also a connecting link of races between the Reformers of the West and the Conservatives of

the East. How small that link is, compared with the whole chain of communication from London to Calcutta and from London to Madras, will surprise many whose attention has not recently been called to the matter. There is actually steam communication the whole distance with the exception of the journey, 550 miles long, from Bagdad through Aleppo and Antioch to Seleucia. The river journey from Bagdad to Bussorah, 300 miles, it is also proposed should be superseded by a railway. The Grand Trunk has granted a concession of this railway, a portion of which, from Seleucia to Aleppo, 90 miles, and the only portion presenting any engineering difficulties, has been thoroughly surveyed and examined with respect to the local traffic, and we are informed by the old advocate of this route, Mr W. P. Andrew, that reckoning its cost at £1,500,000. General Chesney, Sir John M'Neill and a commission of French and English, appointed by the Sublime Porte, reported that the existing goods traffic alone would pay 10 per cent. on the outlay. The estimated cost for the whole line of 850 miles is £8,500,000, and of the line between Bagdad and Seleucia £5,500,000, and of the section between Aleppo and Bagdad £4,000,000 —*Railway News.*

New Alarm Signals for Trains.—M. Herremann has invented a new system of alarm signals applicable for day and night. The ordinary carriage lamp is replaced by a special one, which is lifted above the top of the carriage by a spring acted upon by a button within, while in the day time the same action shows a small flag; in either case a continual peal of bells is produced in aid of the other signals In case of the train being stopped at night by an accident all the lamps may be lifted up, and at once throw a light on the line, and form a signal of distress that would be visible at a considerable distance in the open way.

ORDNANCE AND NAVAL NOTES.

Fethi Bulend, or the Great Victory – During the past week the new Turkish iron-clad corvette "Fethi Bulend," or the Great Victory, has been, by order of the Lords of the Admiralty, officially tried over the measured mile at the Maplin Sands, off Sheerness. The "Fethi Bulend" was built by the Thames Ironworks Company for the Sultan, from the designs of Mr. E. J. Reed, C. B., late Chief Constructor of the Royal Navy. She is the second vessel built from the same designs for the Turkish Government, and both are specimens of a class which Mr. Reed earnestly but fruitlessly pressed upon the attention of the Lords of the Admiralty. The "Fethi Bulend" is of about 1,600 tons burden, with a length between perpendiculars of 235 ft. and an extreme breadth of 38 ft. Her armament consists of four 12½-ton Armstrong guns (Woolwich pattern), and these are enclosed in a central battery, defended all round, and above, by the heaviest armor plating. The vital parts of the ship, such as the engine room boilers, magazines, etc., are protected by 9-in. armor plates, and the less vital parts by plates diminishing from 6 in. to 4 in thickness. All these plates are fixed upon the most substantial "backing." By an ingenious arrangement of the ports, aided by the tapering form of the hull fore and aft, each of the guns, in addition to broadside firing, can be fired in a direct line with the keel, actually commanding a range of from 90 to 95 degrees, and thus giving the ship immense advantages either in chasing an enemy or defending herself from a more powerful pursuer. Her engines are direct-acting horizontal, of 500-horse power nominal, by Messrs. Humphrys, Tennant, and Co. The cylinders are 88 in. in diameter, with a stroke of 3 ft. 3 in. Six runs at full boiler power were made over the measured mile, and a mean speed obtained of 14¼ knots, according to Admiralty calculations. The indicated horsepower was nearly 8½ times the nominal, the maximum number of revolutions being 87, the mean 84, vacuum 25. This highly satisfactory result was obtained with ordinary stokers, ship's coal, and at a most unfavorable state of the tide. The machinery worked in the most perfect manner from first to last, there not having been the slightest approach to overheated bearings. The propeller was a four-bladed Griffiths having a diameter of 16 ft. 6 in., and 19 ft. pitch. The ship, which certainly does not present a very handsome appearance afloat, is simply schooner-rigged, with 2 low masts, and the only presentable object above deck she offers for firing at from a distance is her funnel. It should be added that the "Fethi Bulend," like the "Achilles," is fitted with Rear-Admiral Inglefield's hydrostatic steering gear, by means of which the ship can be steered from almost any point below deck ; so that, literally speaking, not a living soul need be exposed on the upper deck during an action.

The Gatling and the Mitrailleur at Shoeburyness.—We extract from a lengthened account in "Engineering" of several days' experiments with a variety of ordnance, the following account of the closing trial of the series :

The Gatling gun and the French mitrailleur were on trial. These weapons were tried against the 12-pounder and 9-pounder field guns, at known ranges of 800 yds. in the marsh, before targets representing open columns of cavalry and infantry. The details of these experiments will be seen in the table. The targets were 3 rows of boarding, 45 ft. long, 9 ft. high, and placed at distances of 15 yds. behind each other. The 12-pounder gun fired segment shells fuzed with the E. O. C. percussion fuzes with safety pin and cap, as recently improved by Col. Milward, the gun charge being 1 lb. 8 oz. The second row of targeting suffered most severely. The mitrailleur practice was rather wild, the shots for the most part flying high and falling far in the rear of the targets. The practice with the small Gatling gun having 10 barrels of 0.42 in. calibre, was very unfortunate. Two stoppages occurred, which were caused by the front screw of the central bar being too tightly screwed up, and only a comparatively few rounds were got off. Few though they were, they did good work, and proved that the weapon possesses great destructive powers over the mitrailleur. It was stated that the gun had just been received in England; in fact, it only arrived on the ground on Tuesday morning, just before the visitors, and there had been no time to get it in proper order. The 9-pounder bronze gun was fired with shrapnel, fuzed with a new pattern fuze, purely experimental, and which did not answer, two rounds being premature, and one bursting behind the targets.

As we observed in our previous notice, the mitrailleur possesses all the elements of a useful weapon for special purposes in warfare. But it

requires further developing for speed before it can compete with the field guns firing shrapnel or segment shell. The results of the practice show, moreover, that these latter weapons will find a powerful rival in the Gatling gun, of which there are now three sizes at Shoeburyness. During an interval in the programme, the second sized Gatling gun was tried, with astounding results. It is supplied with cartridges by a feed drum revolving on a vertical axis over the firing chamber. The gun was laid at a target on the sands, and 400 rounds were fired in 58 seconds. The target was perfectly riddled, the line of aim having been rigidly maintained. This being the case, it only requires the application of the very nice automatic motion which Dr. Gatling has applied to his smallest gun—the one referred to in the table—for obtaining a continuous horizontal right and left traverse, to constitute a weapon which, subject to the chances of war, would prove to be superior to any other of its class extant. Although these experiments have thrown the mitrailleur somewhat in the shade for the present, they have at any rate develloped and established the power of other resources which England has at her command should the hour of need ever come.

	Weapon.	Range in yds.	No of Rounds.	Elevation.	No. of hits.
1	* 12-pounder gun	800	6	1° 20′	496
2	† Mitrailleur	"	407	..	81
3	‡ Small Gatling gun	"	201	..	82
4	§ 9-pounder gun	"	7	..	254

* Segment shell. Seventh round in gun.
† Shots all very high, mostly over. Another plate ready in gun.
‡ Gun not in working order.
§ Experimental fuzes used, which failed.

A return prepared at the War Office shows that since the adoption of the Snider breech-loading principle 459,553 breech-loading infantry rifles have been produced in this country, the great majority by the conversion of muzzle-loading rifles, and 123,979 carbines and muskets of other descriptions have been produced, also chiefly by conversion, making a total of 583,532 breech-loaders. On August 8, there were 192,362 breech-loading rifles and carbines in possession of the regular and reserve forces, without including the arms supplied to the navy, the Indian Government, or Colonial Governments. On August 8, there were 300,923 breech-loading rifles of all descriptions in store; 247,740 were in the hands of store-keepers at home stations, and 53,183 at foreign stations, excluding India. Regiments have left this country for India armed with 10,956 Snider breech-loaders. Another return relating to rifled guns states the number (the date is a year ago) of serviceable rifled guns to be 5,325, viz., 1,723 muzzle-loading and 3,602 breech-loading; 586 have been fitted and issued for land service, and 1,778 for sea service, and the other 2,961 require no change in the sights to make them available for either service, but simply the addition of a guide plate and crutch, or pin friction, to use them for sea service, and the guns and vents are prepared to receive these fittings; and the whole of the 5,325 guns are available for either land or sea service, the fittings being supplied as required. The return gives a full account of these guns—their class, weight, charges, penetrating power, average endurance, ranges (the highest is 6,915 yds.), and cost, which may run up to more than £2,300. The return goes on to state that the fortifications, as designed, will require 898 large rifled guns and 1,031 guns of 95 cwt. or under. The existing plant of the Royal gun factories is stated to be capable of producing 500 tons of guns of various calibre per month. The time required for the manufacture of wrought-iron muzzle-loading rifled guns is stated as one week for each inch of calibre; thus, a 7-inch gun requires about seven weeks to manufacture it up to proof. This assumes that the guns are being made in numbers, and the factory is well employed (a single gun could not be manufactured in the time named), and that they are of natures of which we already have patterns. A third return, dated August, 1870, states that there are at home 30 field and horse artillery batteries; but they would require a considerable addition to their establishment of horses and men for the wagons requisite on taking the field, but which are not necessary to be maintained in time of peace. The number of field guns in store is given as follows:—Of 20-pounders, 16 cwt., 65, and of these 8 batteries of 6 guns each are complete with carriages; of 12-pounders, BL., 8 cwt., 173; and of 9-pounders, 6 cwt., 60, and of these 14 batteries of 6 guns each are complete with carriages; of 6-pounders, 3 cwt., 14. 10,000 single sets of artillery harness and 3,000 of transport harness are in store.—*Mechanics' Magazine.*

Consumption of Coal on Board Her Majesty's Ships.—The Admiralty have issued a circular (No. 62 N. S.) consolidating all general orders given on the above subject. The mixture of Welsh (or non-bituminous) with North-Country (or bituminous) coal is to be vigilantly enforced in all her Majesty's ships, the necessary alterations having been made in the furnaces for burning mixed coal. These coals are to be supplied to her Majesty's ships in the following proportions:—"For royal yachts, a special supply of Nixon's navigation steam coal will be obtained; for trials at the measured mile, and at the six hours' trial at sea, good hand-picked Welsh coal of any of the following descriptions, viz.: Ynys-faio Merthyr, Davis' Merthyr, Ferndale, Powell's Duffryn, Sqwborwen Merthyr, Fothergill's Aberdare, or Nixon's navigation should be used. The officers conducting the trials are always to report on the trial forms, No. 353, in the place provided for the same on the first page, the description of the coal used, and in the third page in the remarks its qualities as regards—(1) the generation of steam; (2) the emission of smoke; (3) the consumption of fuel; (4) the percentage of ash and clinker. Ships and vessels in the Channel squadron, and on the home station (and in the Mediterranean, if their furnaces have been altered), are to burn one-half Welsh, or non-bituminous, and one-half North-Country, or bituminous, coal; if the furnaces of any ships in the Mediterranean have not been altered, they are to burn two-thirds Welsh and one-third North-Country. All other ships and vessels are to burn two-thirds Welsh, or non-bituminous, and one-third North-Country, or bituminous." With respect to *economy in the use of coal*, the following are the directions given:—"As

a general rule, all ordinary passages and all cruising under steam, except for special steam tactics, are to be performed at rates of speed between four and five knots. No ship, unless ordered to be at a given port by a given date, or unless her safety would be endangered by observing this rule, is ever to steam when she has a fair wind capable of sending her between four and five knots, or when she has a foul wind sufficiently strong to prevent her carrying royals, unless when going in or out of harbor. The maximum supply of coal is to be limited, and the best speed obtainable at that limitation is to be strictly enforced on all ordinary occasions, as follows: For ships which have engines of from 1,200 to 1,350-horse power, the maximum consumption is to be limited to 25 cwt. per hour; for ships which have engines of 1,000-horse power, but less than 1,200, the maximum consumption is to be limited to 20 cwt. per hour; for ships of 800 and less than 1,000-horse power, the consumption is to be limited to 22 cwt. per hour; for ships of 500 and less than 800-horse power, the maximum consumption is to be limited to 18 cwt. per hour. The consumption of smaller ships is to be limited in the same proportion. If a speed of between four and five knots can be obtained by a smaller consumption of fuel than the maximum allowance, it will be the duty of the Commander-in-Chief to enforce the smaller consumption on all ordinary occasions of steaming. When ships have a fair wind, and are using steam, the consumption of coal ought to be reduced; whenever it is allowed, as it often is, to increase, the coal is being wastefully burnt. These instructions are not intended to limit the discretion necessarily given to officers in cases of emergency, but they are to be strictly complied with on all ordinary occasions. These limits of speed and consumption of fuel are not applicable to her Majesty's troop-ships while employed on the Indian overland troop service, or in emergency; but on all ordinary occasions while troops are on board, the speed under steam only is not to be greater than nine knots an hour. At all other times the strictest economy, compatible with the nature of the service, is to be observed in the consumption of coal."

A magnificent four-decker mail steamship has been launched on the Clyde recently, for Burns and M'Iver's Atlantic Mail Service. She was named the "Parthia," is upwards of 3,000 tons, and will accommodate about 1,200 passengers in addition to her crew. The "Parthia" is one of four vessels of similar capacity which this firm intend adding to their present fleet, and which will not be excelled by the steamers of any other company in the world. A new steamer of 2,240 tons was launched recently for the North-German Lloyd's Steam Packet Service, and was named the "Prinz" as she glided off the stocks.

ENGINEERING STRUCTURES.

Isthmian Railroad Enterprises. Mr. Henry Stuckle, a French engineer of high standing, who until lately filled the office of general superintendent of the Alsacian railroads, and who is known to American engineers as the author of "Voies de communication aux Etats Unis," has just published a valuable work upon inter-oceanic transit, which contains some interesting information upon existing and proposed routes of transit across the several narrow isthmuses which unite the American continents. From the mass of valuable information with which the volume is filled, we gather a few facts of interest respecting the railroad enterprises already under construction, which are designed to meet, so far as it can be met by anything less than a ship canal, the necessity for improved facilities for transportation between the two oceans. Of these enterprises three are already under way, the most important of which is the road now building across the Isthmus of Tehuantepec, under a concession obtained from the Mexican Government in January, 1869; and there is every prospect that within a comparatively short time this road will be in actual operation. For many reasons, the Isthmus of Tehuantepec is the most favorable point for the establishment of inter-oceanic communication, whether considered merely with reference to the commerce of this country alone or to that of Europe and the Oriental countries. From Europe, or the Eastern coast of the United States, to the Pacific, it is the shortest practicable route, excepting that of the Pacific railroad, the limited utility of which for the transportation of trans-continental freight has been already demonstrated. As compared with Panama, the Tehuantepec route possesses many important advantages, of which the most important is the saving of distance and time by following the latter, as is shown by the following table showing the length of a voyage to San Francisco from the points named:

	Via Panama.	Via Tehuantepec.	Saving via Tehuantepec.
Liverpool	8,507	7,416	1,131
New York	6,218	4,741	1,477
New Orleans	5,718	3,384	2,334

This line, which will be pushed to completion without unnecessary delay, starts from a point near the mouth of the river Goatzacoalcos, and extends westward to the Pacific. The harbors at both ends of the line are said to be the finest on the coast of Central America—an advantage which cannot be claimed for Panama; and there is every reason to believe that the road will command a profitable traffic in inter-oceanic freights, both American and foreign.

Beside this enterprise, which is entirely in the hands of American capitalists, roads are building across Honduras and Costa Rica. These, however, are regarded as of more importance to the development of the country traversed by them than as affecting the course of inter-oceanic freights. These two isthmuses, situated between Tehuantepec on the North, and Darien on the South, are not favorably located to command any considerable share of the inter-oceanic traffic. The Honduras road, lying some 500 miles south of Tehuantepec, can not present equal advantages with the latter, and the Costa Rica road, lying within 200 miles of the Panama road, is, for many reasons, unable to meet the condition which American commerce demands of an isthmian transit route. The same conditions which determine the relative utility of these competing

railroad lines, will be found to apply with equal force to the much discussed inter-oceanic canal, when our capitalists are ready to undertake that work. Darien would be the most favorable point at which such an enterprise might be located, if it were possible to pierce the unbroken ridge of the Cordilleras at any point where enough water could be procured to fill the upper levels ; but since Darien must be abandoned as impracticable, for the reasons which we gave at length when the project was first seriously discussed by our capitalists, Tehuantepec is the only route which can be followed with advantage to American commerce. A canal at this point would cost more than that proposed at Nicaragua, but the saving of distance over a more southerly route is an important item, and this, with certain topographical advantages, gives Tehuantepec the preference. Two marked features distinguish the topography of Tehuantepec. The first is the depression in the Cordilleras at that point precisely where the isthmus is the narrowest, as if nature herself had desired to facilitate the opening of a water route from sea to sea. The second is the number of large rivers draining the slopes of the mountains on either side, of which the most important is the Goatzacoalcos and its tributaries. Another remarkable circumstance is, that the courses of the rivers in general are in a marvellous degree favorable to the formation of a water way across the isthmus, and that at the summit of the mountainous region, where the waters are divided and flow down on either slope, there exists an abundant supply of water to feed the summit level of a canal. These features of Tehuantepec are worthy of the attention of the Government, and we are glad to learn that the expedition which sails on the 15th of October, under command of Captain R. W. Schufeldt, will make surveys both of this isthmus and of Nicaragua. An impartial report from an intelligent Government officer, based upon actual surveys, would do much to establish public confidence in the practicability of whatever route may be finally adopted ; and if it shall facilitate the opening of inter-oceanic communication, the appropriation of small sums for explorations and surveys will be found a judicious measure of public economy.—*Iron Age.*

SUBMARINE TELEGRAPHS TO THE EAST.—The Telegraph Construction and Maintenance Company have despatched to the East the last instalment of the cables belonging to the British-Indian Extension Telegraph Company, and a section of those for the British-Australian Telegraph Company. The steamship Hibernia sailed for Batavia on the 23d July last with the section to be laid between that port and Singapore. The steamship Edinburgh left on the 21st ult. for Penang, *via* the Cape of Good Hope, with the section to be laid between that point and Madras ; and the steamships Scanderia and William Cory sailed from the Thames on the 7th instant, bound for Singapore, *via* the Suez Canal, with the heavy cable for the Straits of Malacca. The officers and engineers, with the necessary staff, have already proceeded to their respective stations. The submergence of the total length of upwards of 2,400 nautical miles of these cables will commence from Batavia to Singapore, and thence to Madras ; and all the requisite arrangements have been made for these contracts being carried out by Christmas-day next. By that time we may safely anticipate that the Eastern Archipelago will be brought into telegraphic communication, with the present system of submarine cables working so admirably from Falmouth, *via* Gibraltar and Malta, with British India. The manufacture of the China cable, the last of the series, is proceeding rapidly at the Telegraph Construction Company's works, and the arrangements for laying it in the early part of 1871 are completed.

THE WEST INDIA TELEGRAPH CABLE.—Despatches from Cuba state that the laying of the West India Cable had been so far attended with several mishaps. The steamer Suffolk having laid the shallow water cable between Batabano and Key Diego Perez, the Dacia, with Sir Charles Bright on board, was to lay the deep sea cable. Two faults were, however, discovered and the Suffolk was sent to repair the damage. The first fault was found to proceed from a defect in the construction of the cable, and the second was caused by the dragging of an anchor. On the 12th ult. the Dacia was able to commence immersing the deep sea cable, but she had only proceeded four miles when the cable became entangled on a sudmerged rock, and broke. The cable was again taken up, spliced, and relaid, and the Dacia continued her voyage ; but five miles further on the depth of water suddenly changed from 11 fathoms to 200 fathoms, and the cable again parted. The immersed portion was again grappled, but just then it was discovered that another very serious fault existed in the cable between Batabano and Key Diego Perez, at some 40 miles from the former place Sir Charles Bright thereupon buoyed the grappled end, and returned to repair the discovered fault, and this he was engaged doing when last heard from.

The "Times" of September 14, says :—"The West India Cable has been successfully laid between Batabano and Santiago de Cuba, a distance of about 400 miles. Batabano is 35 miles from Havannah, on the southern coast of the island, and Santiago is near its south-eastern end, the cable having been laid from the former to the latter. This success removes a load from the minds of the electricians. According to the latest letters from the cable fleet, apprehensions, were felt as to the practicability of laying the cable in channels so filled with boulders and coral reefs as those on the Cuban coasts. Repeated accidents were happening from those causes, and they were of so serious a nature that it was even proposed to change the route. Success has, however, ended these troubles, and at Santiago there has been much rejoicing. On the night of the 27th of August the harbor was illuminated ; there was a display of fireworks and a torchlight procession in boats. Sir Charles Bright was serenaded by a large party, who, chartering 7 steamers, sailed around the vessels of the expedition Count Valmaseda visited the Dacia, which, with the other vessels, was illuminated. The cable is reported as working finely."

A SUSPENDED TUNNEL IN THE BOSPHORUS.—The enormous traffic from the Stamboul to the Galata and Pera side of the Bosphorus, a continuous stream from morning to night, interrupted only

by the vexations and delays caused by repeated openings and shuttings of the bridges of boats which constitute the connecting line of the two shores, must be considered as a sure indication of the utility and necessity of an uninterrupted communication between the two banks.

A tramway company of ample means has lately started with the intention of transporting both passengers and goods on their various lines, both constructed and constructing on either side of the Bosphorus; but little real profit can be expected to be made till the lines on either side are connected together.

The existing bridges of boats are barely large enough for passengers, so that permission cannot be obtained by the Company to lay down their rails thereon, besides which the constant interruptions would be highly prejudical. The enormous depths of the water, the precipitous banks, and the well-known twenty or thirty feet of mud which forms the bottom, quite forbid the idea of tunnelling in the ordinary way, it being impossible to get down low enough, even with the stiffest gradients. One of the chief engineers of the Turkish Government (Mr. Hadden) has therefore suggested a very simple yet effective mode of overcoming these difficulties.

He proposes to suspend or float a tunnel at about 35 ft. below the surface of the water, allowing uninterrupted passage to vessels of the largest tonnage. There is no tide in the Golden Horn. The tunnel would consist of a wrought iron tube, about 10 ft. in diameter, and 1,200 ft, long; the tube to be cellular, and each cell perfectly independent, or the tube may be lined with wood. The gradient at either end would be one in fifty.

The tube will weigh about 600 tons; maximum weight of any train 400 tons; concrete and lining, to overcome the buoyancy of the tube, 1,700 tons; water displacement, 2,700 tons.

It will be readily seen that when the tunnel is unused there will be a buoyancy or upward strain of 400 tons, which is to be neutralized by holding down chains, which will act precisely like inverted piers or supports. When a train traverses the tunnel, if of less weight than 400 tons, it is evident that no deflection can take place; and on the train leaving the tunnel the chains prevent the reaction of upward deflection which would without their holding-down power naturally ensue. In the drawing the tunnel is represented as held down at only *three* points, but any number may be used. It is proposed to name the tunnel "Daoud," after the present talented Minister of Public Works, Daoud Pacha.—*The Engineer.*

New Smoke-Preventing Boilers.—An important invention has just been patented by Mr. Arnold, of Barnsley, and Mr Carnelly, of Manchester, by which a boiler is so constructed that by a peculiar arrangement of the flues no smoke is emitted into the chimney. The invention has just been tested at the works of Jackson Brothers, of Barnsley, and with such success that whilst the smoke was thoroughly consumed there was a saving in fuel of nearly one-third, as compared with the ordinary boilers, whilst imposing no additional labor on the fireman. The patent boiler has two self-contained fire-boxes or furnaces, and instead of a bridge, as in an ordinary two-flued boiler, there is placed a stoppage or end to the fire-box, by which the flame or draught is arrested in its usual course, and conducted through two transverse openings—one on each side of the fire-box. The gases that are evolved are caused to pass through the openings named underneath the boiler into what is termed a combusting chamber, where the incandescent gases ignite into a flame of intense heat and brightness, thus preventing the formation of smoke, seeing that it is an admitted and well-known fact that when smoke is once formed it is impossible to burn it, though it should pass through a white heat. From the combusting chamber the flame is conducted into a second tube chamber, where are inserted a number of what are called Arnold's vertical tubes of 3 in. lap-welded. The fire-box and back flues are separated by a water-space, and those being self-contained give great strength to the boiler, and render the collapsing of the tubes almost impossible; also, in consequence of the old bridge being done away with, a greater amount of heating surface is obtained from the same amount of fuel. The immense heating surface obtained by the thorough burning of the carbon confirms the calculations of MM. Farre and Silberman, who completed the researches of Dulong. They found from their experiments that the pound of carbon imperfectly burned, producing carbonic oxide, gave 44,000 units of heat, whereas one pound of carbon entering into complete combustion, producing carbonic acid, gives 14.500 units of heat.

The principles embodied in the new boiler are those which have been advocated by all the most celebrated engineers and chemists of the last 20 years, but have never been carried out in their full entirety until now. Of the other advantages claimed by the patentees are that the working of it requires no extra care in firing, for the most careless stoker would fail to create a nuisance in the production of smoke. The invention, which can be applied to any existing boiler, either Cornish or cylinder, combines simplicity, efficiency, strength, and economy; is self-acting, and not liable to get out of order. Practical men, who have witnessed the working of the new boiler and apparatus, are unanimous in the opinion that the invention is a valuable one, and will, no doubt, be pretty generally adopted.—*The Mining Journal.*

NEW BOOKS.

Architectural Iron Construction. By W. & T. Phillips. 1870. For sale by Van Nostrand.

This little work, the first of a series, ought perhaps rather to be called a "Handy-book upon the Use of Wrought Iron," as its object is not so much to propound any new theory, or to introduce any new formula, as to methodize and apply in a practical and accessible manner the results and deductions of other larger and more elaborate works on the strength of materials and the theory of strains.

The work, when complete, will consist of five parts 1. Beams and Girders, the pamphlet before us. 2 Fire-proof Floors. 3. Roofs. 4. Buildings. 5. Bridges.

The first part, now published, commences by comparing the various formulæ for timber, flitch beams, cast-iron beams, riveted beams, calling attention to Phillips's Patent, and finally dealing with beams of homogeneous rolled wrought iron. The formulæ are quoted *in extenso* in each case, and some examples are given showing the com-

parative cost, strength for strength, of the different materials. Lattice girders have also a special formula adapted for them, and the various advantages attending their use in certain situations are clearly pointed out and illustrated by the plate.

A valuable part of the book will be found on page 17, which contains a table showing the safe distributed load in tons, etc., for clear spans or bearings, from 7 ft. to 40 ft. in the clear, of solid rolled girders, varying in depth from 4 in to 12 in.

Given the weight to be carried and the bearing in the clear, a reference to this table will at once give the requisite section, large or small, of wrought iron required to do the work, and its weight per foot run.

To the educated and practised engineer the work is no more than a handy book of reference, but we cannot help thinking that, though really a trade book, it embodies in a concise and accessible form information that will be valuable to architects and builders, in regard to its subject matter.

INTEROCEANIC CANALS, an Essay on the Question of Location for a Ship Canal across the American Continent. By HENRY STUCKLE, late Superintendent of the Alsacian Railroads. New York: D. Van Nostrand; London: B. F. Stevens; Paris: E. Dentu.

This book of 140 pages presents the following subjects in their order: Present state of interoceanic communication in America; the Suez Canal and the proposed American ship canal; the problem to be solved by an American ship canal; the most advantageous location with reference to the interests of the United States.

The last chapter is the most valuable of the series, as it presents an epitome of the advantages afforded by the Tehuantepec route, in which the results of former surveys and estimates are carefully summed up.

Three maps illustrate the text.

THE NEW ELEMENTS OF HANDRAILING. By ROBERT RIDDELL. Philadelphia: Claxton, Remsen & Haffelfinger. London: Trubner & Co., Paternoster Row. For sale by Van Nostrand.

In conclusion, we can cordially and safely recommend "The New elements of Handrailing" to the sober attention of the building mechanics of this country. To one and all it will be found most useful. It dispenses with useless lines, simplifies the method, places everything clear to the understanding, bases construction on unerring scientific principles, and thus it is a valuable medium and auxiliary in the technical education and moulding of the skilful and practical workman.—*The Builder.*

TABULATED WEIGHTS OF ANGLE, T, BULB, BEAM, ROUND, SQUARE, AED FLAT IRON, FOR THE USE OF NAVAL ARCHITECTS AND SHIPBUILDERS. By CHAS. H. JORDAN, M. I. N. A. London: E. & F. N. Spon, 48 Charing Cross. 1870. For sale by Van Nostrand.

One of the most useful little books that an engineer cas possibly have in his office is "Penn's Tables." But Penn, unfortunately, goes no farther than bars and plates. He does not touch upon angle, T, channel, H, or any other section of iron that is peculiarly well adapted for the resistance of strains of compression. Mr. Jordan endeavors in the half dozen pages composing his publication to supply the information not to be found in the tables of Penn. The manner in which he has chosen to accomplish his task is scarcely so happy as it might have been. Every draughtsman who has had to make an estimate of an iron bridge, roof, or other structure of that material, in which angle iron is certain to enter as one of the principal forms, knows how to calculate the weight of that form of section. Briefly, the angle iron is treated as a plain bar. The sum of the sides, minus the thickness, reduces the angle iron at once to a bar equal to that breadth, and of the same thickness. This is nearly the course followed by Mr. Jordan; whereas, for the tables to have been of real utility in the office, the dimensions of the different sections should have been given. In fact, Mr. Jordan's tables do not give us the weight of any angle iron, but the weight of a bar equivalent to it in sectional area. This is not what is wanted. For example, take an angle iron $3\frac{1}{2}$ in. by 3 in. by $\frac{1}{2}$ in.; this is equivalent to a bar 6 in. by $\frac{1}{2}$ in., which weighs 10 lbs The sum of the sides is equal to $6\frac{1}{2}$ in Consequently if we turn to Mr. Jordan's tables we shall find that the breadth of flanges $6\frac{1}{2}$ in. by $\frac{1}{2}$ in. also weighs 10 lb. But the real labor to be saved is the adding together of the flanges, and as these half dozen pages do not save that labor, they have done little or nothing towards facilitating the calculation of the weights of different sections of iron. Tables that pretend to give the weights of angle irons should enter them with the proper dimensions, that is, with the breadth of each flange in a separate column. An angle iron 3 in. by 4 in. should read in the tables 3 in. by 4 in., and not 7 in. If this were done in a revised edition, the little book would be of much value, The labor would be nothing, as the present calculated weights would all stand as they are. At present, Penn's tables supply all that Jordan's profess to do.—*Engineering.*

RESEARCHES ON THE ACTION OF THE BLAST FURNACE. By CHARLES SCHINZ. Translated from the German, with the special permission of the author, by WM. H. MAW and MORITZ MULLER. London: E. & F. N. Spon. For sale by Van Nostrand.

The author is not a metallurgist, but, as he explains in his preface, being ardently devoted to the art of measuring heat, and applying it rationally in the various branches of industry, he naturally made the manufacture of iron an object of study.

His published papers have been widely copied by leading scientific papers in Europe and America.

Aside from the value which the present work bears to the iron worker, it presents to the practical chemist an excellent model for method of investigation in many other processes in which combustion plays an important part.

PEWTNER'S COMPREHENSIVE SPECIFIER.—A Guide to the Practical Specification of every Kind of Building Artificers' Work. Edited by WILLIAM YOUNG, Architect. London: Longmans, Green, and Co. 1870. For sale by Van Nostrand.

This book is addressed to the student, to the builder, and to the architect. To the student, as a manual by which he can become familiarized with the technicalities of the profession to which he is devoting himself, with all the various requirements met with in its practice, and the method in which instructions from the architect are given to the contractor. For the builder and architect the

volume is intended as a manual which shall not be found wanting in supplying information respecting building work in all its details ; and to render it more valuable especially to the two latter classes, a complete and well arranged index is added. There are 694 clauses in the book, of which 637 are devoted to general specifications, and the remainder to conditions in compliance with which the works particularized in the previous portion of the volume are to be executed.

As a rule, we have found that such compilations as Mr. Pewtner's are very far from satisfactory, or even useful, for they contain those things they ought not to contain, and omit those things which they ought to contain, a failing discouraging in itself, and likely to produce mistrust of all other similar publications. To a considerable extent, however, this standard fault of such volumes of reference has been avoided in Mr. Pewtner's book, and the catalogue and description refer to almost every conceivable subject connected with the architect's and builder's business.

The book is well classified, and the main object at which it aimed has been, we think, successfully attained, that of giving in as few words as possible the necessary amount of information upon each subject treated, which is rendered in concise terms, always an advantage in drawing up a specification. We recommend the volume to architects, builders, and students, the three classes to whom it is addressed, believing that they will find it valuable for reference, and that it will frequently be the means of saving valuable time.

La Dynamite, Substance explosive. Inventée par M. A. Nobel. Collection de documents rassemblée, par Paul Barbe. Paris, 1867.

Les Grandes Usines : Etudes Industrielles en France et a l'Etranger. Par Turgan. Paris, Michel Leray Freres.

These beautiful volumes, as they appear in succession (one each year), fulfil the promise of the first issue, which appeared in 1863. They are of royal octavo size, and contain about 350 pages each. The metallurgical and chemical manufactures are beautifully illustrated, the cuts extending across two pages in order to represent an entire interior of a factory on a scale sufficient to exhibit the details of the process, or in many instances of the machines.

The typography and illustrations are of the same quality as "La Vie Souterraine," and "Guillemin's Heavens."

8 vols. from 1863 to 1869 inclusive. For sale by Van Nostrand.

MISCELLANEOUS

Lead Smelting Furnaces.—Reference was made in the Journal of August 27 to an improved furnace, invented by Mr. George Metcalf, of the Petusola Foundry, near Spezia, Italy, and in successful operation there ; it is now proposed to give a brief description of the invention itself the object of which is to expedite and facilitate the operation of obtaining lead from its ores. For this purpose a furnace is used divided longitudinally for a portion of its length by a vertical partition or wall extending upward to the crown of the furnace, but not extending to the grate or fire-bars, so that a chamber with a bed is left near the grate or fire-bars extending the entire breadth of the furnace, and having no partition at that part. The compartments formed by the partition have at their ends arrangements for opening and closing communication between them, and ducts or uptakes leading thence into the chimney. The charges are placed in the compartments formed by the partition, and are gradually fed forward to the fire chamber or bed in front of the fire-bars. The draught is shut off from each compartment alternately, one compartment being open to the chimney, while the other is closed, so that while one set of charges are exposed to the free current of flame, or aeriform or gaseous products of combustion rushing from the fire through the compartment towards the chimney the other set of charges are subjected only to the action of dead heat, because the draught apertures at the end are closed. The lead as it is fed in dries and becomes calcined, and wholly or partially desulphurized, as it is passed gradually along the chamber, and at length it reaches the bed or chamber in front of the fire-bars. The greatest portion is then removed, in a state of slag or agglomeration, through an opening in the furnace, fitted when opened, with a removable spout down which the slag descends into a wagon, and is run off therein to a blast-furnace, in order to be again subjected to heat for metallurgical purposes.

The advantage claimed for Mr. Metcalf's furnace is that less heat is required, and consequently less fuel is expended, and the furnace is better preserved. The lead that remains in the furnace is removed by tapping the furnace, and allowing the molten lead to run out. The bed of the furnace is by preference constructed of a peculiar curved form, and in order to get out all the lead, in case of the furnace bed leaking or becoming destroyed, a false door is used parallel with the tapping-door and screwed thereto, the interval between the two doors or plates being filled with bone-ash, or other non-conducting material. Thus, if the furnace-bed gets destroyed or leaks, and the lead runs through it, the lead or metallic product can be withdrawn through the false door. The novelties claimed for the invention are the employment of the partition extending for a portion of the length of the furnace, so as to form two passages as already, the employment of the two tapping-doors, and the general arrangement of the parts.

It will readily be understood that, as already stated, four charges are continually under treatment – two on the preliminary side of the partition, and two on the finishing side. These charges average $1\frac{1}{2}$ ton of ore, and as one charge is drawn every six hours, it follows that each charge is 24 hours in the furnace. The result of the treatment is declared by competent judges to be as near as may be perfect. The loss by volatilization is much less than usual, and the saving of fuel is enormous, 5 tons with the new furnace doing quite as much work as 26 or 28 tons with the old reverberatory furnace. The wear and tear of material and plant is reduced by two-thirds, and the manual labor is certainly not greater than under the old systems, and is much more simple. The more favorable results obtained with Mr. Metcalf's furnace is accounted for by the fact that by its use, instead of burning the lead (thereby producing smoke and vapor), the lead is, by not being brought under the action of heat so intense as in the old systems,

not volatilized or oxidized, but simply metallized. The invention is generally considered one of the most important yet introduced.—*Mining Journal.*

The Folkestone-Boulogne cable has been repaired and is now working. No private messages can now be received for Paris itself, but for Italy and the South of France the communication is still open.

It is stated that the company for the submersion of a new cable between this country and the United States will be brought forward directly after the conclusion of the war between France and Germany, as well as many other new undertakings which for the time remain in abeyance.

The China Submarine Telegraph Company have notified a postponement of the payment of the remaining capital, and that the same will now be payable in six instalments of £1, commencing on the 1st of October, and continuing each month till the 1st of March. This will not affect the laying of the cable by the 30th of June, 1871, the time fixed by the contract.

The St. Pierre-Duxbury section of the French Transatlantic cable, which was broken in May last, has been successfully repaired by the Joint Anglo and French Company's maintenance steamer Robert Lowe, Captain James Blacklock. Communication by all three cables of the Joint Atlantic Companies between London and New York is thus completely re-established.

The Government are giving evidence of their intention to increase the telegraphic communication between Great Britain and Ireland. The steamship Monarch and the powerful tug-steamer Blazer have arrived in Donaghadee harbor, county Down, having on board a telegraph cable and all the necessary apparatus for its submersion between Donaghadee and Portpatrick. It is to be laid alongside the cable which at present crosses at that point. In consequence of the severe weather the Monarch and the Blazer could not start on Tuesday upon their voyage, but as soon as the storm subsided the paying out was to commence.

The Telegraph Construction and Maintenance Company have despatched to the East the last instalment of the cable belonging to the British Indian Extension Telegraph Company, and a section of those of the British Australian Company. The screw steamer Hibernia sailed for Batavia on the 28th of July last with the section to be laid between that port and Singapore. The screw steamer Edinburgh left on the 21st ult, for Penang, *via* the Cape of Good Hope, with the section to be laid between that port and Madras, and the screw steamer Scanderia and William Cory sailed from the Thames, bound for Singapore, *via* the Suez Canal, on the 7th inst., with the heavy cable for the Straits of Malacca. The submergence of a total length of upwards of 2,400 nautical miles of these cables will commence from Batavia to Singapore, and thence to Madras, and all the requisite arrangements have been made for these contracts being completed by Christmas Day.

The West India Cable has been successfully laid between Batabano and Santiago de Cuba, a distance of about 400 miles. Batabano is 35 miles from Havannah, on the southern coast of the island, and Santiago is near its south-eastern end, the cable having been laid from the former to the latter. Apprehensions were felt during the work as to the practicability of laying the cable in channels so filled with boulders and coral reefs as those on the Cuban coasts. Repeated accidents happened from those causes, and they were of so serious a nature that it was even proposed to change the route. Success, however, has ended these troubles, and at Santiago there has been much rejoicing. On the night of the 27th of August the harbor was illuminated; there was a display of fireworks and a torch-light procession in boats. Sir Charles Bright was serenaded by a large party, who, chartering seven steamers, sailed around the vessels of the expedition. Count Valmaseda visited the Dacia, which, with the other vessels, was illuminated. The cable is reported as working well.—*Railway News.*

Leather Paper in Japan.—One of the most interesting and peculiar productions of paper is that which is made to imitate leather. The surface has every appearance of a finished skin, with extraordinary firmness and elasticity, and it can be subjected to washing without any injury from the water. These peculiarities are not so much due to the superior quality of the material, as to the mode of manufacture, the surfaces remaining intact, even when the paper is very thick, while with us paper of this kind soon loses its firmness, and the grain is impaired.

Japanese leather paper is made extensively at Flangawa, near Yeddo. It is made in sheets of 60 centimetres in length and 42 centimetres in width. The paper out of which it is prepared is not dissimilar to our packing paper, and is made in Southern Japan, near Nagasaki, and thence taken to other provinces, where it is manufactured into the different forms for various uses. The leather paper is made in the following manner: It is dampened and laid in pairs between two peculiarly prepared forms, made of paper also, only more highly varnished than ordinary leather paper; they have a very strong surface coating, but running only in one direction.

Before putting the paper in these forms, the sheets are stretched a little in the direction of their width. If there are several sheets, they are rolled on a cylindrical piece of wood, the grain of the paper running in an opposite direction from that of the wood; they are then unrolled from this on a cloth to keep them in shape, and put into a form with a hole in the top large enough to admit the end of the wooden cylinder. The roll of paper is then subjected to a pressure of 200 or 300 lbs. After the roll has been reduced to three-quarters of its original length by this pressure, it is taken out of the press and turned, the folds flattened out and again pressed, to remove the deep marks.

After passing the paper through rollers several times, the upper surface acquires the appearance of leather; it is then colored, oiled with a kind of rape seed oil, varnished, put once more in the press, which completes it, with the exception of drying. By means of parallel or cross lines on the rollers, the upper surface of the paper is made to resemble leather exactly in all its varieties. The paper being pressed to one-third, or even to one-half its original thickness, and the passage through the rollers giving it a fine-grained appearance, makes it valuable to picture printers, as the surface has the appearance of crepe silk.

There is another variety of leather paper which is smooth and transparent, resembling hog-skin very much. This is manufactured by a process of hammering, and is the highest priced, costing 27 cents per sheet, while the other ranges from 8 to

14 cents, some very fine selling at 8 cents per sheet.—*Journal of Applied Chemistry.*

Poisonous Lead Pipes.—We have recently heard, says the "Architect," of two or three very serious cases of lead poisoning arising from the use of lead cisterns and lead pipes for storing and conveying water. It seems strange that the old-fashioned lead pipe should continue to be used when a lead-encased block tin pipe, possessing all the good qualities of leaden pipe (such, for instance, as strength, ductility, durability, and cheapness), and having none of its objections, has been before the public for some time past. We allude to Haines's patent lead-encased block tin pipe, which is being supplied at the current market price of ordinary lead pipe of similar bore. With reference to the strength of the block tin pipes we have seen the result of some experiments recently made by Mr. Kirkaldy, which prove to demonstration that the bursting strain of the lead-encased tin pipe is nearly 50 per cent. greater than that of the ordinary lead pipe; and it has also been discovered as the result of experiments made recently at the offices of the Glasgow Waterworks. that the cohesive strength of block tin pipe was considerably more than double that of ordinary lead pipe. The same result was subsequently arrived at from experiments made at the Liverpool Waterworks, so that we have conclusive evidence that Haines's pipe is much more capable of resisting the expansive action of frozen water than the common lead pipe. Our readers would probably be interested to know the process of manufacture. A hollow cylinder of lead is cast; at the moment of hardening, and before it is completely cooled, a mandrel, equal in dimensions to the contemplated bore of the pipe, is inserted, and the space filled up with tin in a state of fusion. When the ingot thus prepared is nearly cool it is placed in a hydraulic press planned to receive it, and the pipe is forced through by mechanical pressure, which being applied equally over the interior and exterior surfaces, the homogeneity of the metal is perfectly sustained throughout. The average length of pipe thus obtained without a flaw is about 150 ft. As the pipe is running through the press it is carefully watched, and the instant an irregularity in the surface is observed the length is cut off. The tin lining must, of necessity, be perfect throughout, for the moment the tin ceases to draw, a wave or irregularity is observed in the lead, and the pipe is at once removed.

We are informed that the men are very careful not to allow any pipe to pass out of the press with a flaw, as the terms of their contract with their employer provide that if there is discovered, when the inspection is made before the pipe is put in stock, the slightest flaw in a length of pipe, the men are not paid for its manufacture. It will readily be seen that as tin melts at a lower temperature than lead some difficulty would arise in soldering. But this is easily obviated by the employment of a solder of which cadmium forms a sixth part. We are informed that the manufacturers are about to supply a solder made in the proper proportions.

Other attempts have been made at various times to coat lead with tin, but with very little good result. Tin has been applied by the electro-plating process, and by the more general method of drawing the leaden pipe through a bath of molten tin, but in each case has been found unsuccessful. The tin has washed off after a short use in consequence of its not having thoroughly united with the lead.

During the last twelve months the large chimney at the Goole Alum and Smelting Co.'s works has been subsiding owing to the intense heat from the furnaces, until it became about four feet out of the perpendicular. The chimney, which is a very handsome erection, is about 200 ft. high, consequently in subsiding to such an extent it assumed a very dangerous aspect; and it was only a question of time as to when it would pass the centre of gravity and fall. Mr J. Berger Spence determined a short time ago to bring the chimney back again to its original position, by cutting out a layer of bricks, about two-thirds of the way round, and about twenty feet from the base. When this layer of bricks had been taken out, strong iron wedges were introduced, and a thin layer of bricks put in the place of the course of bricks extracted. When this had been accomplished, the wedges were then drawn out, and the stupendous structure came over with crushing weight on to the new made bed. assuming its original position. The plan which has been adopted, although very dangerous, has proved perfectly successful, and the calculations have been made with such nicety that no one can detect a single flaw in the chimney.

Relative Purity of Air.—In the annual report of Dr. Angus Smith, the Inspector under the Alkali Act, there are some results of his analysis of air which are worth recording. He remarks that although the estimation of oxygen and carbonic acid in various atmospheres may be used to teach us much, and the mode of analysis is very exact, there are still a few points requiring elucidation. If, for example, some of the oxygen existed in a state of condensation, the amount combining with hydrogen would appear as a greater percentage on the whole than if it existed as oxygen gas. It is abundantly established that air does differ in the amount of oxygen, but the differences are very small in appearance when stated in percentages, the streets of London being almost as pure apparently as the hills of Scotland. The percentages of oxygen and of carbonic acid respectively in the air in various places and under various conditions are shown in the subjoined table:

OXYGEN.	Per cent.
N. E. sea shore and open heath (Scotland)	20.9990
Tops of hills (Scotland)	20.9800
In the suburb of Manchester in wet weather	20.9800
In the suburb of Manchester in wet weather	20.9600
St. John's, Antigua	20.9500
In the outer circle of Manchester, not raining	20.9470
Low parts of Perth	20.9350
Swampy places, favorable weather, France and Switzerland	20.9220 to 20.9500
In fog and frost in Manchester	20 9100
London, open places, summer	20.9500
In a sitting-room which felt close, but not excessively so	20.8900
In a small room with petroleum lamp	20.8400
Ditto, after 6 hours	20.8300
Pit of theatre, 11.30 P. M.	20.7400
Gallery, 10.30 P. M	20 8600
About backs of houses and closets	20.7000

In large cavities in metalliferous mines (average of many)	20.7700
In currents in metalliferous mines (average of many)	20.6500
Court of Queen's Bench, Feb. 2, 1866	20.6500
Under shafts in metalliferous mines (average of many)	20.4210
In sumps or pits in a mine	20.1400
When candles go out	18.5000
The worst specimen yet examined in a mine	18.2700
Very difficult to remain in for many minutes	17.2000
CARBONIC ACID.	
In mines—largest amount found in Cornwall	2.5000
Average of 339 analyses	.7850
In theatres, worst parts, as much as	.3200
In workshops, down to	.3000
About middens	.0774
During fogs in Manchester	.0679
Manchester streets, ordinary weather	.0403
Where fields begin	.0369
On the Thames at London	.0343
In the London parks and open places	.0301
In the streets	.0380
On hills in Scotland from 1000 to 4406 ft. high	.0332
At the bottom of the same hills	.0341
Hills below 1000 ft	.0337
Hills between 1000 and 2000 ft	.0334
Hills between 2000 and 3000 ft	.0332
Hills above 3000 ft	.0336

THE MARVEL OF STEAM ENGINEERING.—This little machine, which is a rotary steam engine, certainly combines the maximum of power in the minimum of space, and seems likely to go far toward superseding the piston engine. Thus, for economy of space, we have an eight-horse engine with governor attached; the entire engine, enclosed within a circular case, 28 in. diameter by 2 in. wide, and looking not unlike an ordinary grindstone when hung in a frame. The principle upon which the invention is based is the same as that involved in the turbine water wheel, with the essential difference, however, that the engine consists of two wheels within one case, rotating in opposite directions with equal force and speed—one, the outer wheel, being driven by the direct action of steam upon buckets extending around the inside surface of its rim, and the other by the reactive force of the steam which escapes from two tubular radial arms, bent and flattened at their ends, from which the steam is discharged. This latter wheel has a hollow journal, connected with the supply steam pipe by a stationary steam-tight sleeve, through which the steam is led to the hollow axle or journal of the wheel. These wheels, therefore, have equal velocity and power, and each has a pulley attached, from whence belts are carried to the counter shaft, one of the belts being reversed or crossed. The advantages of this ingenious piece of mechanism are numerous: It costs but one half the price of a piston engine; economy of space, and weight, a thirty-horse engine weighing but 800 lbs.; simplicity of construction, having no valves, eccentrics, cut-offs, or connecting rods; and, moreover, that no engineer is required to run it, any one competent to fire and watch a boiler being sufficient. For farm labor, hoisting purposes, drilling, factory uses, etc., this engine must become valuable, and a very slight adaptation of boiler, with the consumption of the exhaust steam, to avoid noise, would make it a most valuable motor for our city railway cars. The specimen visited was certainly not larger than an ordinary circular cheese, and was yet driving a fan blower and a circular saw of 30 in. diameter, with power to spare. Although not an entirely new invention, having been in use for two years, it is well worthy of notice, and to many of your readers would be a valuable and economical a dition to the workshop.

WITHIN the past few weeks there has been a discovery of bismuth in the deepest part of the Crown lode at Botallack. This mineral, by its quality of imparting hardness, is useful in the formation of several alloys. It is used (or ought to be) in type, pewter, Newton's metal, solder, and largely for electro-types. The present "find" was worth from 12s. to 14s. per lb. when smelted, and most of it was rich stuff, and is only a little bunch. The late Mr. Joseph Carne, in a paper which, up to that date, was exhaustive of the productions of St. Just, records that native bismuth had been found in two of the tin and copper lodes of Botallack, up to 1822, but that the best of the specimens for the mineralogist's cabinet had ceased, and only inferior ones were at that time discovered. The present specimens agree with Mr. Carne's description of the auriferous sulphuret of bismuth, then as now found in the Crown lode. The miners of half a century ago, as a few weeks since, ascertained the presence of the metal by thrusting the mineral into an ordinary fire, when it oozed out in small globules.

NILS ERICSON.—The Swedish "Aftonbladet" of the 8th inst. contains the following notice of the celebrated Swedish engineer, Nils Ericson:—"With this great constructor of canals and railways, Sweden has lost not only its greatest engineer, but also one of its best men in every respect Nils Ericson has written his name in the history of civilization of Sweden, and as long as an engine runs through the valleys of Sweden, and as long as a vessel safely passes the wild water-falls of Trallhattan, his name will be kept in grateful remembrance. His father was Olaf Ericson, an ironmaster at Langbanshyttan, in Wermland, who had two sons—Nils, born in 1802, and his brother John, in 1803, both of whom have done so much credit to their country. Nils, as an administrator and constructor of canals and railways, John, still living in America, and well known through his many inventions in mechanics and naval architecture. John Ericson's greatest engineering works are the Swedish Government railways construction, the reconstruction of Trallhatta Canal, the Dachs at Stockholm, and the Canal Saima in Finland.

EXPLOSIVE COMPOUNDS.—Mr. A. Nobel, a Parisian engineer, has taken a patent for improvements in the composition and fabrication of explosive compounds for mines. It is to be hoped that some day means may be found to utilize without too much danger the terrible power of nitro-glycerine. The success which has been achieved with steam which caused at the outset such deplorable accidents, aids the hope to a certain extent. Mr. Nobel seems to have made an important step in the right direction as regards the use of nitro-glycerine for mines. The following shows the composition of two types of his powder: (1.) 68 parts of pulverized nitrate of barytes, 12 of

charcoal, of light texture; 20 of nitro-glycerine.—(2.) 70 parts of barytes, as above; 10 of powdered resin; 20 of nitro-glycerine. The charcoal should be carbonized at a low temperature, and, consequently still containing hydrogen. An addition of 5 to 8 per cent of sulphur to either of the above mixtures gives a powder which fires more briskly, but, at the same time, it increases the danger in the manufacture, carriage, and application of the powder, which should not be lost sight of. The method of using these powders is to place them in cartridges like firework cases, covering the powder with a little fulminant, such as mercury for example, before closing and priming. The cartridge has merely to be placed in the hole, and covered in the usual manner, and it may be fired either by a fuse or the electric spark; in either case the fulminating powder, acting on the nitro-glycerine, inflames the whole of the contents instantaneously. To render carriage of the cartridges less dangerous, a little ordinary gunpowder may be substituted for the mercurial fulminant.

The "Instrument Room" of the Electric Telegraph.—This room, the most sensitive spot in the whole world—the cerebrum which receives and transmits intelligence from all quarters of the globe—may be looked upon as one of the most curious sights in the metropolis. Although hundreds of minds are simultaneously conversing, some with tongues of steel, some with the clear sound of the bell, some again by means of piano-like notes, which spell the words letter by letter although we have the clatter of all these sounds mixed with the metallic tinkle of the electric bell, hailing from distant western and northern cities—not a human voice is heard—although, stranger still, the manipulators are all women. According to the rules of the service, the swifter they talk the better; but it must be done in silence with some unseen correspondent at the extremity, it may be, of the kingdom—a necessary condition in order to insure attention and accuracy whilst the operators are at work. It is certainly no unpleasant sight to see these young women doing the work of the world, proving that they are capable of thoughtful labor, and trustworthy in circumstances of great pith and moment. It is discovered at last that the sewing needle is not the only instrument they can master. They are evidently drawn from the middle rank of life; and we are informed that they make capital manipulators, the delicacy of their fingers seeming to point out to them the telegraph instrument as a suitable means of employment.

Whilst the visitor is listening to the clatter of one half of the world talking to the other half, he is aware of a dull thud striking from time to time upon the ear. On inquiry, he finds this strange sound proceeds from the pneumatic tube, the new servant the electric telegraph has called to its aid; and within a glass case against the wall he sees trained just like so many fruit trees in an orchard house, long tubes of gutta-percha, ending in an oblong shaped mouth, covered with thick plate-glass. As he is watching, a long round pellet is projected into this reception case with the force of a spent shot, taken out by the clerk in attendance, and immediately opened. It contains a telegraphic message, sent here for transmission to some other wire. This pneumatic tube at present is only extended to offices half a mile round but as this half mile is in the busiest part of the city, an area in which it is difficult to get along fast by foot passengers, porterage work is done in seconds as compared to minutes by this fleet mechanical messenger. Eventually all the great district post-offices will be connected with the central office by pneumatic tubes, thus vastly accelerating the speed of the telegrams. In addition to the offices within half a mile of Telegraph street, which are thus served by this aerial Mercury, the head office at St. Martin's-le-Grand is provided with a tube. The great submarine cables such as the Atlantic, the Indian, and all the marine lines wishing to use the central office as a means of forwarding messages, will have lines of tube to this room for that purpose. If the reader remembers his old pea-shooter days, he will understand their principle of action in a moment. If he blows he impels the pea, if he sucks he draws it up into his mouth. Pressure and suction are the two forces used in this pea or message-shooter of our maturer days. The telegraph message comes in a round plug-box, covered with carpet or flannel, so as just to make it fit loosely the tube. The suction and propulsive power lies in the depths of the establishment, in the shape of a steam engine.—*Edinburgh Review.*

The temperature of the past summer months has attracted so much attention to the thermometer, that we presume the following summary, from the observations of Prof. Morris, of this city, will not be wanting in interest.

The average temperature of June was 3.54 deg. higher than the mean average of the past ten years, but was slightly below the average of either June, 1860 or June, 1865.

The average for July, was 2.09 deg above the average of the last decade but was below the averages of the same month, 1864, 1865, or 1866. In the latter year, July was nearly a whole deg. hotter (0.85 deg.) than the average given above.

August was 2.82 deg. above the ten year average, but was below the temperature of the same month of 1863 or 1864. In both of these years, August was 1.1 deg higher.

The average temperature of the summer of 1870, was 76.434 deg. Of the last ten years, two summers have been warmer; the average of 1864 having been 76.936 deg., and that of 186-, 77.396 deg. The popular judgment, however is to some extent justified by the tables which show our last summer was 3.9 deg. warmer than the mean for ten years. It was also 3.78 deg. above the mean of the last quarter of a century.

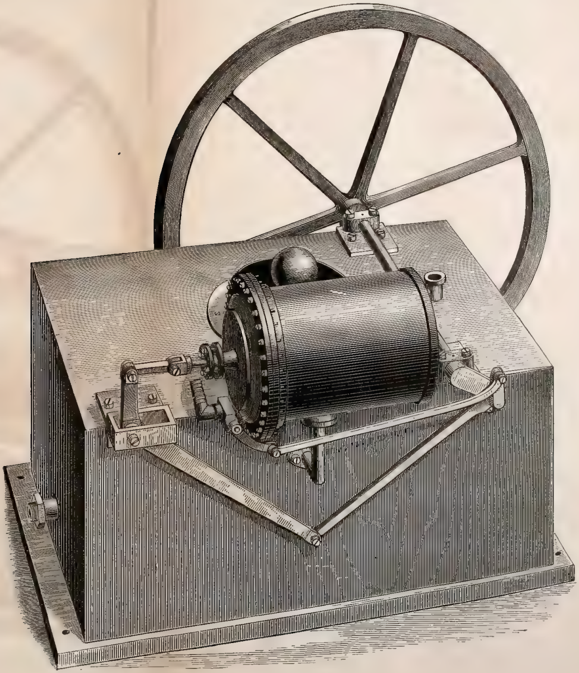
The extremes among the averages for 25 years were 77.396 deg. in 1865, and 70.064 deg. in 1849.

M. E. Duchemir has sent to the Academie des Sciences the description of a marine battery, which, when plunged in the sea, gives off large quantities of electricity. It is a modification of the electrical buoy tried at Cherbourg.

What is considered as an improved alloy for stereotyping purposes, on account of its ready fusibility and greater hardness than that usually made with bismuth, is composed of 50 parts of lead, 36 of tin, and 225 of cadmium.

Captain Ericsson's Solar Engine.

[See Page 579.]



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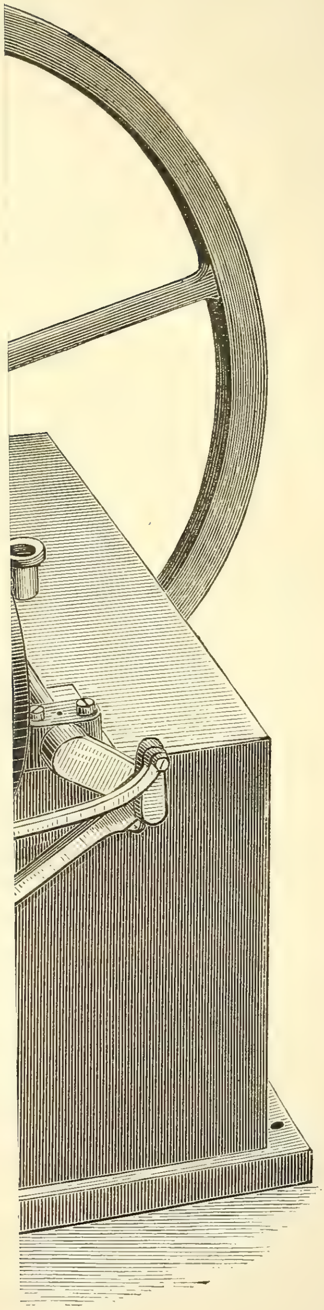

VAN NOSTRAND'S
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SOLAR HEAT.

BY CAPTAIN JOHN ERICSSON.

From "Engineering."

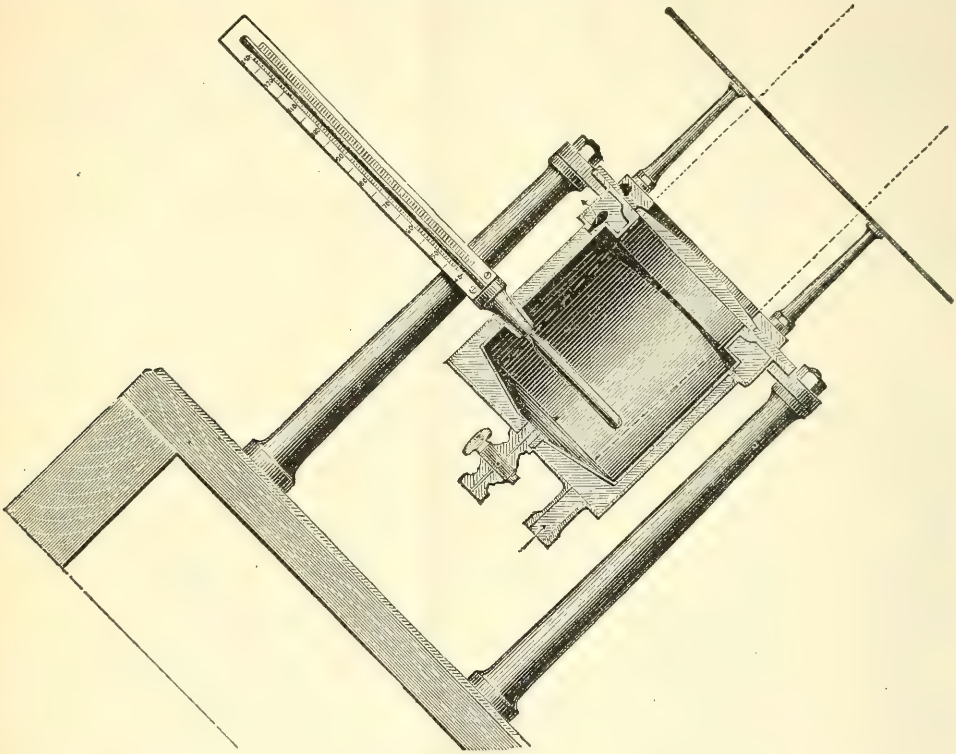
The accompanying illustration represents a longitudinal section of an actinometer which I have constructed for the purpose of ascertaining the intensity of solar radiation near the surface of the earth. It will be evident, on reflection, that experimental researches relating to the sun's radiant heat require that the intensity should be known at every moment, if possible, by mere inspection, since it is continually changing.

During the early part of my investigations I lost much time for want of reliable means of ascertaining the actual intensity of the rays at the moment of observing the effect of the sun's heat on the instruments employed. To be brief, the observed results all conflicted, no two observations tallying, thus involving the whole question in uncertainty and confusion. The causes which affect the intensity of the heat imparted to substances exposed to solar radiation are chiefly the sun's zenith distance, on which depends the depth of atmosphere to be penetrated by the rays; the temperature of surrounding objects, and of the immediately surrounding atmosphere, which radiate heat towards the exposed substance, these temperatures being modified by a variety of circumstances wholly beyond control—clouds and aqueous particles in the air—and possibly the intensity is affected by an irregular evolution of heat in the solar atmosphere. Travellers who have made observations within the tropics state, in order to point out the great intensity of the sun's rays in places where they descend vertically, that, while the temperature in the shade marks 83 deg. it frequently exceeds 150 deg. in the sun, thus indicating an intensity of solar radiation fully 67 deg. The observations of Daniell, frequently referred to in works on Meteorology, conducted in the latitude of Washington, where the depth of the atmosphere at the summer solstice is only 0.038 greater than on the ecliptic, are so instructive that I subjoin his Table on solar radiation throughout a day in the month of June:

Time.	Temperature. In sun.	Temperature. In shade.	Difference.	Time.	Temperature. In sun.	Temperature. In shade.	Difference.
a. m.	deg.	deg.	deg.	p. m.	deg.	deg.	deg.
9.	93	68	25	2.	143	75	68
9.30	103	69	34	2.30	138	76	62
10.	111	70	41	3.	138	76	62
10.30	119	71	48	3.30	132	77	55
11.	124	71	53	4.	124	76	48
11.30	125	72	53	4.30	123	77	46
12.	129	73	56	5.	112	76	36
12.30	132	74	58	5.30	106	75	31
1.	141	74	67	6.	100	73	27
1.30	140	75	65				

A glance at this Table shows that, according to the adopted method of determining the intensity of solar radiation by

deducting the temperature indicated by a thermometer in the shade from the temperature attained in the sun, the radiant heat is less powerful before than after noon. The differential temperature, or solar intensity, at 9 A. M., according to this Table, is 25 deg. while at 3 P. M., with very nearly an equal zenith distance and equal depth of atmosphere to penetrate, the solar intensity is shown to be 62 deg. I will not detain the reader by explaining the causes of the errors of Daniell's Table, my object being simply to point out the gross imperfection of such a mode of determining solar radiation as that of noting the different indications of shaded and



exposed thermometers. During the early stages of my investigation before adverted to, I adopted this method of ascertaining the actual intensity of radiant heat; but, notwithstanding numerous expedients resorted to in order to prevent the thermometers from being unduly influenced by the radiant heat of the air and surrounding objects, I failed to secure satisfactory results. The most important point—the controlling the radiation of the surrounding air, which affects the exposed as well as the shaded thermometer—having presented obstacles which no mechanical arrangement whatever could overcome, I have adopted the expedient of wholly excluding the atmosphere. By this means the bulb of my actinometer is surrounded by the ether alone, the molecular motion of the solar ray being thus permitted to regulate the temperature, free from atmospheric influence. It will be objected that the bulb of the thermometer cannot be applied within a vacuum without the employment of some transparent covering, and that, consequently, the energy of the rays will suffer considerable loss before reaching the instrument. To meet this objection I apply a thin lens of 40 in. focus, inserted at such a distance from the bulb that the gain by concentration will exactly balance the loss of calorific energy attending the passage of the rays through the crystal.

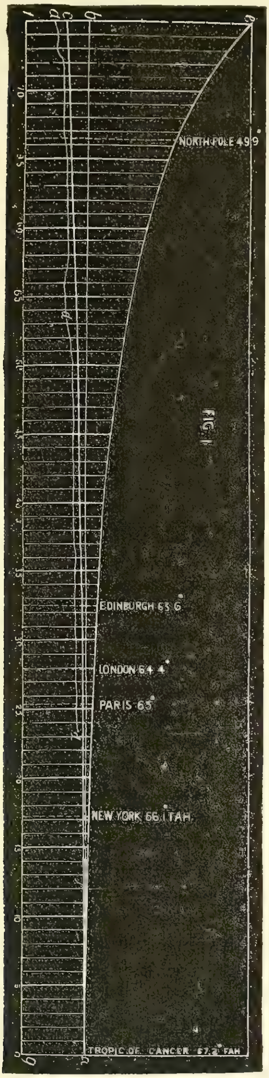
A close inspection of the accompanying illustration, together with the foregoing statement relative to the object and nature of the lens, and the applying the

thermometer within a vacuum, render a minute description of the actinometer superfluous. This instrument, like the solar calorimeter, is attached to a table, the face of which is kept perpendicular to the sun during observations; provided likewise with mechanism by means of which the sun's zenith distance may be ascertained at every instant. The chamber containing the bulb of the thermometer is $4\frac{3}{4}$ in. in diameter, plated with polished silver, and surrounded with a double casing, through which a current of water is circulated by means precisely like those employed in the solar calorimeter, the vacuum being also produced in a similar manner, and flexible pipes employed for connecting the instrument with the stationary pumps, to admit of the necessary compound movement of the table. The cistern which supplies the circulating water is kept at a constant temperature of 60 deg. and in order to secure perfect accuracy, the thermometer employed for regulating this temperature is so applied that the return current from the actinometer to the cistern circulates round its bulb. A thin metallic screen of annular form, supported by four columns, and plated with silver, protects the instrument from the sun's radiant heat, for the purpose of economizing the cooling medium required to keep the circulating water at the proper temperature. The opening in the screen corresponds with the size of the lens. The bulb of the thermometer is three in. in length, in order to expose the greatest possible surface compared with its contents. The upper half of the bulb is coated with lampblack, the lower half being exposed to the action of the reflected rays from the bottom of the chamber, in such a manner that the radiation of this lower bright half of the bulb is neutralized by reflected heat.

Before turning the instrument to the sun, the vacuum gauge should be inspected, and the water from the cistern should be permitted to run freely through the casing for several minutes until the temperature of the return current and that indicated by the actinometer correspond. The table being then turned to the sun, the expansion of the contents of the elongated bulb will in a few minutes indicate with absolute certainty the intensity of the sun's radiant heat, independent of atmospheric temperature and the multitude of disturbing causes which render the indications of solar intensity by common thermometers mere approximations. In view of the foregoing explanations, it is hardly necessary to state that the zero of the thermometric scale of the actinometer is 60 deg. above Fahrenheit's zero, and that whatever point is reached by the mercurial column of the actinometer above its zero, after turning the lens toward the sun, can only be attained in virtue of the power of unaided solar radiation. It will be well to bear in mind that the bulb is surrounded by ether alone, freed from all disturbing influences of gaseous matter, and that the heat which determines the zero of the actinometer is supplied by radiation from the instrument itself. The necessary illustrations not having been yet presented, the question of actual intensity cannot now be entertained. It will, nevertheless, be proper to observe, that the actinometer merely shows the thermometric interval of solar intensity on Fahrenheit's scale, without reference to the position of that interval on a scale which commences at the accepted "absolute zero." I regard this absolute zero, however, as an *ignis fatuus*, retreating as fast as we approach it. In support of this, it will be proper to mention that the law of decrease of temperature in the inverse ratio of the square of the distances, together with my actinometer observations, which determine the actual diminution of solar intensity for the increase of 0.0334 of the distance between the sun and the earth, during the summer solstice, warrant the assertion that solar intensity on the surface of Neptune is far below our as umed absolute zero. Neptune receives light from the sun; can there be a doubt that this planet also receives *heat*, although of an intensity below absolute zero?

It only remains to be stated that my observations with the actinometer have been made in lat. 40 deg. 42 min., thus only 17 deg. 12 min. from the tropic of Cancer. The depth of atmosphere so near the tropics being, at midsummer, only 0.047 greater than on the ecliptic, while the sun's zenith distance on lat. 40 deg. 42 min. during the winter solstice is only 2 deg. 18 min. less than at the pole at midsummer, I have been enabled to determine the maximum

intensity of solar radiation for all latitudes from the equator to the pole. Fig.



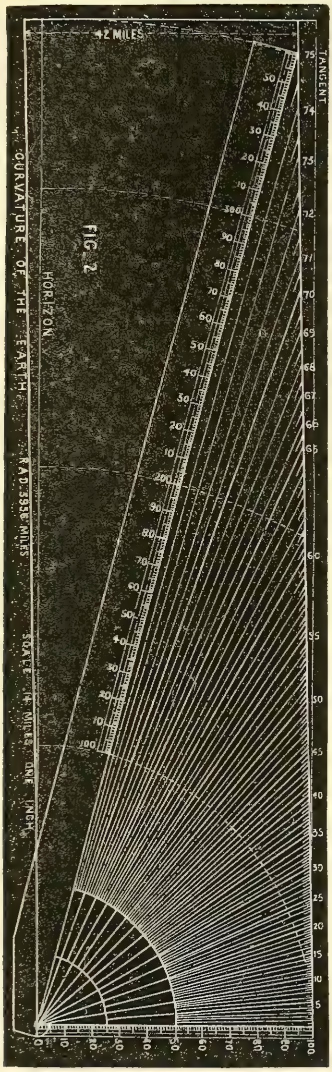
1 is a diagram presenting the relations of atmospheric depth and solar intensity for each degree of zenith distance to the 75th degree. A brief description will suffice to render this diagram easily comprehended. The ordinates between the curve *e a* and the base line, *f g*, exhibit the true proportions of the depth of the atmosphere from the vertical to 75 deg. zenith distance; while the ordinates of the curve, *c a*, indicate the relative intensity of the sun's radiant heat at the summer solstice, for each degree of the sun's zenith distance from the vertical to 75 deg. The straight line, *b a*, is the tangent of the curves, *e a* and *c a*. It will be seen by closely examining these curves, and the ordinates resting on the base line, *f g* (comparing the same with the figures in the accompanying Table), that the intensities of solar radiation vary in the inverse ratio of the cube roots of the atmospheric depth. The ordinates between the irregular line, *d d d*, and the base line, *f g*, show the solar intensity for each degree of zenith distance from 23 deg. to 75 deg., ascertained by actinometer observation 5th of August, 1870. With reference to the solar engine this irregular line, *d d d*, possesses great interest, as it indicates the available solar energy, for mechanical purposes, during a day when the sun is obscured with *cirri* of unusual density.

The engineer will regard this diagram as a solar indicator card, the space below the line, *d d d*, representing the available power, while the space contained between that line and the curve, *c a*, indicates the loss. For the purpose of elucidation, the North Pole, together with the cities of Edinburgh, London, Paris, and New York, have been introduced on this diagram, their positions having reference solely to the depth of atmosphere and solar intensity during the summer solstice. The accompanying Table shows the depth of atmosphere and maximum solar intensity at midsummer for each degree of the sun's zenith distance from the vertical to 75 deg. (See page 566.)

The observed solar intensity for each degree of zenith distance from 23 deg. to 75 deg. August 5th, 1870, has been introduced into this Table, as before stated, to enable us to determine what amount of radiant heat is lost when the sun's rays are obstructed by *cirri* of considerable density.

Fig. 2 represents a graduated plate furnished with a movable radial index, to enable the observer to ascertain quickly the depth of atmosphere corresponding with observed zenith distances. The graduated plate is constructed to a scale of 14 miles to the inch, the curvature of the earth's surface and the atmospheric boundary 42 miles above the earth being accurately laid down agreeable to the scale mentioned. It will be seen that the vertical depth of the atmosphere has been di-

vided into 100 equal parts, and that the same graduation has been introduced on the movable index. Accordingly, by placing the index at angles corresponding



with the observed zenith distances, the intersection of the top line of the atmosphere with the edge of the index will show the relative diagonal and vertical depth.

As far as ascertained by means of the actinometer, there is an appreciable difference in the sun's energy for corresponding zenith distances early in the morning and late in the afternoon, which cannot be traced to any adequate physical cause. I have accordingly attempted to explain the discrepancy on the ground that the orbital motion of the earth occasions a very considerable advance towards, and retreat from, the solar wave early A. M., and late P. M. The subject will be readily understood by reference to Fig 3, which represents a section of the earth through the plane of the ecliptic, the line *d e* indicating the orbit, and the straight arrow the earth's course ; while the curved arrow shows the direction of rotation; *a b c*, etc., represent the sun's rays ; the orbital velocity during a definite period being represented by *f g* and *k l*. Let us assume that the latitude of the point *f*, on the earth's surface, is such that the prolongation of the ray *a h* to *g*, makes *h g* three times longer than *f g*. It will now be evident that the ray *a h*, which has been arrested at *h*, must, while the earth advances from *f* to *g*, continue its course at a rate three times greater than the earth's orbital velocity, in order to reach *g* simultaneously with *f*. Assuming the mean distance of the earth from the sun to be 91,430,000 miles, the orbital velocity will be 96,120 ft. per second ; hence the ray *a h*, to keep up with the retreating western quarter of the globe, must move at the rate of 288,360 ft. per second. The advancing eastern quarter obviously imparts a retrograde movement to the solar wave, consequently the ray *m l* will, on grounds already set forth, be pushed towards the sun at the rate of 288,360 ft. per second. We have thus established a difference of advancing and retreating velocity exceeding 600,000 ft. per second, for the lower altitudes, which unquestionably interferes with the regularity of the solar wave, and thereby tends to disturb the uniformity of the intensity of the sun's radiant heat towards evening. Meteorologists will account for the observed diminution by pointing to the fact that during sunshine —without which the actinometer cannot be used—the atmosphere, in most localities, gradually becomes charged with vapor as the day advances ; and that dust and other light dry particles are carried up into the atmosphere by the ascending heated current of air, thus obstructing the sun's rays. These plausible reasons lose their force if we consider that during the season most favorable for actinometer observations, the vapors are held fast

within icy boundaries, and that the dust is buried under the snow.

The extraordinary velocity of light, nearly 1700 times greater than the velocity shown by the foregoing demonstration, will be urged as a reason why the disturb-

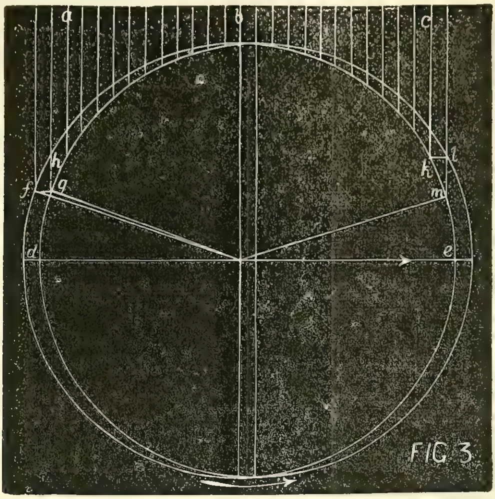


FIG 3

ance of the solar wave could not be practically appreciable. I cannot accept this objection as conclusive unless it can be shown that the dynamic energy imparted by solar heat is not partially the result of arresting the motion of the rays. The following facts connected with the subject, demand serious consideration. Owing to the orbital motion of the earth, the lens of the calorimeter, while exposed to the radiant heat, sweeps across the path of the sun's rays at the rate of 96,120 ft.

Zenith distance.	Depth of atmosphere.	Maximum intensity.	Observed intensity, Aug. 5, 1870.	Zenith distance.	Depth of atmosphere.	Maximum intensity.	Observed intensity, Aug. 5, 1870.	Zenith distance.	Depth of atmosphere.	Maximum intensity.	Observed intensity, Aug. 5, 1870.
deg.		Fahr.	Fahr.	deg.		Fahr.	Fahr.	deg.		Fahr.	Fahr.
Vertical.	100.	67 20									
1	100.	67.20	....	26	111.1	64.86	58.4	51	157 7	57.72	50.7
2	100.	67.19	....	27	112.1	64.67	57.5	52	161 2	57 31	50.6
3	100.1	67 18	....	28	113.2	64.48	57 7	53	164.8	56.89	45.8
4	100 2	67 16	....	29	114·1	64.28	57.7	54	168 6	56.46	45.4
5	100.3	67 12	....	30	115 2	64.07	57.8	55	172 6	56 02	45 6
6	100.5	67 08	....	31	116 4	63 85	56 9	56	176 9	55 56	44.6
7	100.7	67.02	...	32	117 6	63.63	56.9	57	181.5	55 09	47.0
8	101 0	66 96	....	33	118 9	63.40	56.7	58	186.4	54.60	48 0
9	101.3	66 90	....	34	120.3	63.16	57 0	59	191 6	54 10	47 3
10	101 6	66.84	....	35	121.7	62.92	56.8	60	179.0	53 58	47.4
11	101 9	66.77	....	36	123 2	62 67	56.4	61	203 7	53.05	46 4
12	102.3	66 70	....	37	124 8	62 40	56 2	62	209 8	52.50	46 8
13	102 7	66.62	....	38	126 5	62.11	55.8	63	216.4	51.90	46.8
14	103.1	66 54	....	39	128.3	61.81	56.1	64	223 5	51.40	46 4
15	103.6	66.44	....	40	130.2	61.50	55.0	65	231.2	50.81	46.1
16	104 1	66 33	....	41	132.2	61.19	54 8	66	239.8	50.20	45.0
17	104 6	66.21	....	42	134.2	65.88	54.8	67	249 0	49.57	42 6
18	105.1	66 08	....	43	136.3	65.57	54.9	68	259.1	48 91	43.1
19	105.7	65 95	....	44	138.4	60 25	54.6	69	270.1	48.25	43.2
20	106.3	65.82	....	45	140.6	59 93	54.7	70	282 1	47.55	42 8
21	107 0	65.68	....	46	143.1	59 60	54 5	71	295.2	46.84	41.9
22	107.7	65.53	....	47	145.7	59.25	54.4	72	309.7	46.12	40.4
23	108.5	65.38	59 5	48	148.5	58 88	53.4	73	325.5	45.37	33 5
24	109 3	65.22	58 4	49	151 4	58 51	53 0	74	342.8	44.60	36.3
25	110.2	65 04	57.7	50	154.5	58 12	53.2	75	362.4	43 78	32.4

per second; hence the fluid contained within receives the dynamic energy resulting from the extinguished *vis viva* and molecular motion of a countless number of rays following each other in an inconceivably rapid succession.

Pouillet having ascertained the number of units of heat imparted to the water in his pyrheliometer of one decimetre (3.93 in.) diameter, imagined that he had measured the force of a sunbeam of 11.9 square inches section; whereas, in reality, he had at the end of his experiment of five minutes' duration, accumulated a force generated by extinguishing the *vis viva*, and receiving successively the molecular motion of the entire number of rays contained in a passing sunbeam, the section of which may be ascertained by multiplying the orbital advance of the earth during five minutes—28,836,000 ft.—by the diameter of the pyrheliometer, 3.93 in. = 9,443,790 square feet.

NEW YORK, *September* 6, 1870.

DETERMINATION OF THE UNIT OF OBLIQUE PRESSURE.

By C. LE BLANC.

Translation from "Annales du Port Chausèes."

If the resultant P of a pressure makes an angle a with the normal to the resisting plane, the usual method employed to find the pressure upon a unit of surface is by resolving normal and parallel to the plane; the parallel component is neglected, and the normal taken into account.

The writer has shown, in an article on oblique arches published in the "Annales des Ponts et Chausées" in 1856, that this method is wrong; and that the plane is subjected to normai pressures whose resultant is a force of which the orthogonal projection is is the oblique resultant of the pressures, equivalent to

$$\frac{P}{\cos a}.$$

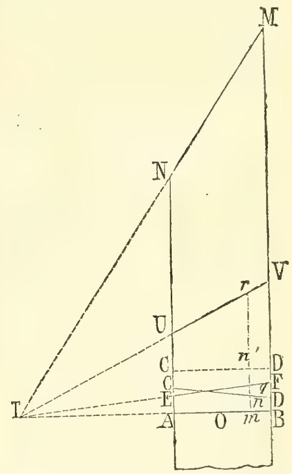
This view seems to have met slight recognition, the usual method having been employed in many articles since published in that periodical. Yet this method may mislead to insecure construction; for, as the friction angle of masonry is generally greater than 30°, a structure may be considered secure, in which the resultant of the pressures upon a joint includes an angle of 30° with the normal. In this case the pressure upon a square centimeter found by the old method is less than the real pressure in the ratio of the quotient (cos 30°), *i.e*, about 30 per cent; viz.—6 kilog., instead of 8 kilog.

The object of this paper is to show that the old method is erroneous.

Preliminary Considerations.

If a solid body in the form of a right prism with an end-surface F is fixed to a supporting plane, with its axis horizontal, and subjected to a uniformly distributed pressure upon one end whose resultant R is parallel to the axis, the operation of weight in the direction of the axis is null, if the original height was H, and it is redu-

FIG. 1.



ced by pressure to H, the regular diminution of length, $\frac{H - H'}{H}$, until the limit of elasticity is reached is in a constant ratio to the unit pressure $\frac{R}{F}$, so that

$$\frac{R}{F} = E. \frac{H - H'}{H}$$

E being the modulus of elasticity. In this case upon removal of pressure the body is restored to its origiinal length, which is not the case if the limit of elasticity has

passed. For a tensile load Rt, the same holds true, so that

$$\frac{\mathrm{R}t}{\mathrm{F}} = \mathrm{E}' \; \frac{\mathrm{H}' - \mathrm{H}}{\mathrm{H}}. \qquad (1)$$

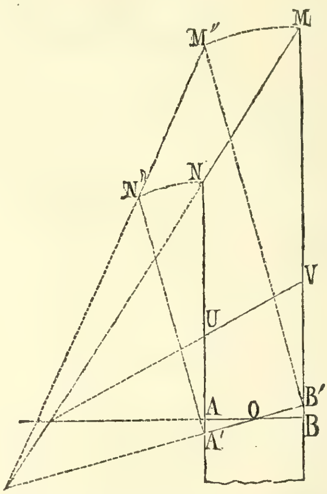
If the tensile or compressive forces are not constant along the length of the prism, but vary continuously, the prism may be considered as divided into horizontal laminæ of infinitesimal thickness, and the above equations apply to each of these.

In all calculations of resistance the dimensions of the several parts of a structure must be determined so that the molecular variations in length may not exceed certain limits of elasticity ; and this may be done by finding the direction in which the alteration in length is a maximum and applying the above equation. This equation expresses the fundamental law of all construction ; it is therefore important that it should be understood, and it should not be forgotten that this equaon holds only on the hypothesis that the ction F has a normal position to the force R. But it often happens that the unit pressure for a section oblique to the resultant strain has to be determined. If the usual process is followed in which only the normal component of the resultant is sought for, the above equation gives the contraction normal to the section, but not the maximum contraction, which takes place in the direction of the resultant. The decomposition into normal and tangential components only serves to determine whether sliding will take place in the sectional plane. If the friction prevents this, cohesion has unhindered action, and the strains in the section must be otherwise considered.

Rectangular sections and position of the resultant in a plane symmetrical to the section plane.

Suppose a vertical prismatic column of homogeneous masonry of sectional area, F, limited by an oblique section M N, which is normal to two parallel faces of the prism ; let us determine what is the relation to the limits of elasticity of a point within the column at a distance H$'$ from the upper edge of the section. We consider the effect of gravity upon an element between two sections, one passing through the point O, the other at the infinitesimal distance η. This element is made shorter by the pressure of the part of the column above, but not uniformly, since the effect is not uniformly distributed. Both limiting planes have suffered deformation ; but it can be assured, according to Navier's hypothesis, that the surfaces have remained plane. It follows from the symmetric position of the normal plane with respect to the oblique plane which passes through the axis of the column, that both limiting planes remain normal to the plane of symmetry ; hence the relative shortening $\frac{\eta - \eta'}{\eta}$ is constant through the whole horizontal extent of the cutting plane O. It is therefore only necessary to find the law of contraction in the trace of the cutting plane O with the plane of symmetry, and to consider the point O as a point of this trace.

FIG. 2.



In Fig. 2, let A B be the trace of the cutting plane O, with the plane of symmetry, C D that of the second bounding plane of the element, A N and B M those of the prism faces normal to the plane of symmetry, C$'$, D$'$ the trace of the original second limiting plane of the element before compression by gravity. The distance m' n' between A B and C$'$ D$'$ is η, that between A B and C D η' ; and $\frac{n\,n'}{m\,n} = \frac{\eta - \eta'}{\eta}$.

In the trapezium A E F B, which is formed, if A E = C C$'$, B F = D D$'$, $m\,q = \mu\,\eta' = \mu - \mu'$, and is proportional to the relative contraction of the element. The ordinates of the line E F represent

the corresponding contractions of the several points in the line A B.

If L is the length of the section,
e, its resistance,
l, the distance of a point from A B,
p, the unit pressure upon this point in the direction of the greatest contraction, the pressure upon the element $e\,d\,l$ is $p\,e\,d\,l$, and we have

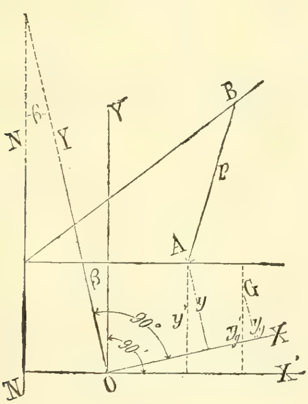
$$\frac{p\,e\,d\,l}{e\,d\,l}=p=\mathrm{E}\frac{\eta-\eta'}{\eta}$$

Putting

$$m\,r=m\,q\frac{\mathrm{E}}{\eta}=\frac{\mathrm{E}}{\eta}(\eta-\eta')=p,$$

and drawing from r a straight line to the intersection F of the lines A B and E F, the ordinates of the line U V are proportional to those of the line E F, and are numerically equal to p. We have then but to determine the line U V in order to find the unit pressure in the direction of greatest compression of every point of the line A B. The determination is easily made as follows :

FIG. 3.



In Fig. 3 let A N M B be a vertical section of the column along the plane of symmetry O ; A B, U V have the same reference as in Fig. 2 ; R be the weight of the upper portion of the column, or the resultant of the pressures upon the plane O ; we then have

$$\int_0^l p\,e\,d\,l=\mathrm{R}.$$

If the distance of the resultant R from A B is represented by G.

$$\int_0^l p\,e\,(l_1\ l)\,d\,l=\mathrm{R\ G}.$$

If p is the ordinate of the side U V of the trapezium, and s the surface of this trapezium, g being the distance of its centre of gravity from M B, we have

$$\int_0^l p\,e\,d\,l=e\int_0^{l_1}p\,d\,l=e\,s$$

and

$$\int_0^l p\,e\,(l_1-l)\,a\,l=e\int_0^l p\,(l_1-l)\,d\,l=e\,s\,g$$

$$e\,s=\mathrm{R}\text{ and }e\,s\,g=\mathrm{R\ G, or}$$

$$(2)\ s=\frac{\mathrm{R}}{e}\text{ and }(3)\ g=\mathrm{G}\,;$$

consequently, the surface of the trapezium is equal to the weight of the portion of the column above the section O, for the unit of resistance, and the resultant passes through the centre of gravity of the trapezium.

Both relations (2) and (3) express the line U V as a function of R and G, and as these magnitudes are easy to determine, the solution of the above follows of course. We now confine ourselves to the expression of the contraction at the point O, and the unit pressure in the direction of the greatest contraction as a function of G and R. If, in Fig. 3, h = B V, and h_2 = A U, we have

$$s=\frac{h_1+h_2}{2}\,l_1,\text{ and from (2)}$$

$$\frac{h_1+h_2}{2}\,l_1=\frac{\mathrm{R}}{e},\text{ or }\frac{h_1+h_2}{2}=\frac{\mathrm{R}}{e\,l_1}$$

consequently it appears that, independent of G and of the point of application of the resultant R, the unit pressure in the axis of the column is as great as if the resultant R were uniformly distributed.

Again, if h is the ordinate of a point in U V, and l its distance from the line A B, we have

$$h=h_2+\frac{h_1-h_2}{l_2}\,l.\qquad\ldots\quad(5)$$

therefore

$$s\,g=\frac{h_1+h_2}{2}\,l_1\,g=\int_0^{l^1}\left(h_2+\frac{h_1-h_2}{l_1}\,l\right)(l_1-l)\,dl$$

and

$$g=\frac{h_1+h_2}{3\,(h_1+h_2)}\,l_1\qquad\ldots\quad(6)$$

and from (3)

$$\mathrm{G}=\frac{h_1+2\,h_2}{3\,(h_1+h_2)}\,l_1$$

from (4) and (7)

$$h_1=\frac{\mathrm{R}}{l_1\,e}\cdot\frac{2}{l_2}\,(2l_1-3\,\mathrm{G}),$$

$$\frac{\mathrm{R}}{l_1\,e}\cdot\frac{2}{l_2}\,(3\,\mathrm{G}-\ _1),$$

substituting in (5)

$$h = \frac{R}{l_1 e} \cdot \frac{2}{l_1} [l_1(3\,G - l_1 + 3\,\lambda\,(l_1 - 2\,G)]$$

or

$$h = \frac{R}{F} \cdot \frac{2}{l_1}\, l_1(3\,G - l_1 + 3\,\lambda\,(l_1 - 2\,G)], \quad (8)$$

if λ stands for the value of l at the point O.

Again in Fig 1 let B m=H, A n =H_2; we have by (6) and (3) from the trapeziums ABUV and ABNU

$$\frac{H_1 + 2\,H_2}{3(H_1 + H_2)}\, l_1 = \frac{h_1 + 2\,h_2}{3(h_1 + h_2}\, l_1$$

or

$$\frac{H_2}{H_1 + H_2} = \frac{h_2}{h_1 + h_2}$$

$$\frac{H_1 + H_2}{H_2} = \frac{h_1 + h_2}{h_2} \text{ or } \frac{H_1}{H_2} = \frac{h_1}{h_2},$$

Hence the lines UV and NM intersect at the same point in the line AB; and if that part of a vertical between AB and NM be indicated by H and the corresponding pressure in this vertical by h, we can put h=KH, K being a numerical constant. We then have

$$\int_0^{l_1} h e d l = \int_0^{l_1} \pi\, H e d l$$

or

$$K e \int_0^{l_1} H\,d\,l = \pi\,\varepsilon \int_0^{l_1} d\,l$$

$$\therefore K = \pi \text{ and } H = \pi\, H.$$

It follows that the Navierian hypothesis for the normal section of the column cannot be correct, if it does not hold for any section. This may be proved generally; but it is sufficient here to do so for an oblique section normal to the plane of symmetry.

Such a plane cuts the plane of symmetry obliquely if the column is not under the action of gravity. To determine what position any point of this oblique section would take under the influence of gravity, we consider this point as belonging to the right section in which it is situated. We see that it has descended η=η_2; but this is proportional to p or h, and since h=πH, η—η is proportional to H, or the depth of the given point below the end surface; hence the geometric locus of the point is a straight line.

We have now to obtain the unit pressure at O in the direction of the maximum pressure. This must lead to the same value of p or h, as equation (8); for the pressure is independent of the section by means of which it is found. Our new method of calculation indeed leads to the same value.

In Fig. 3 let A′B′ be the oblique section, Q the angle of this plane with the right section AB, R′ the resultant of gravity upon A′B′NM. According to the new method we have to substitute for the oblique resultant R′ the pressure $\frac{R'}{\text{Cos } a}$ normal to the section, which is to be considered as the resultant of the elementary pressures normal to A′B′ in a distribution according to Navier's hypothesis. The weight of a column A′B′N″M″ normal to A′B′, in which the action of gravity becomes parallel to the edges of the column, fulfils these conditions, provided that the direction of the weight of A′B′N″M″ (parallel to B M) pierces the plane A′B′ in the same point in which the direction of the weight of A′B′NM (parallel to B M) pierces it.

Let L″ be the length of A′ B′,
F″ its area,
λ″ the distance of O from the line A′ N″,
G″ the distance of the point of application of R′,
s, l, and λ, meaning as before;

We obtain by (5) for the unit pressure h' of the section A′ B′, bearing the column A′ B′ N″ M″.

$$h' = \frac{R'.\,\frac{1}{\cos a}}{F''}\; \frac{2}{l_1''^{\,2}} [l_1''(3\,G'' - l_1'') + 3\,\lambda''\,(l_1'' - 2\,G'')]$$

and since

$$F'' = \frac{F}{\cos a'},\; l_1'' = \frac{l_1''}{\cos a},\; \lambda'' = \frac{\lambda}{\cos a'},$$

$$G'' = \frac{G'}{\cos a}, \text{ we have}$$

$$h' = \frac{R'}{F} \cdot \frac{2}{l_1^{\,2}} [l_1\,(3\,G - l_1) + 3\,\lambda\,(l_1 - 2\,G')]. \quad (9)$$

On the other hand, if we regard O as belonging to right section A B, (8) gives

$$h = \frac{R}{F} \cdot \frac{2}{l_1^{\,2}} [l_1\,(3\,G - l_1) + 3\,\lambda\,(l_1 - 2\,G)].$$

To show the equality of h and h', we must express R, G, R′, and G′ as functions of the same magnitudes. In Fig. 3 let B M = H, A N = H_2, B′ M = H'_1, A′ N = H'_2, and π = the weight of the unit volume of the column; then

$$R = \pi\,F\,\frac{H_1 + H_2}{2} \text{ and } R' = \pi\,F\,\frac{H_1 + H_2}{2},$$

Again (6) applied to A B N M and A′ B′ N M gives

$$G = \frac{H_1 + 2H_2}{3(H_1 + H_2)} l_1 \text{ and } G' = \frac{H_1' + 2H_2'}{3(H_1' + H_2')} l_1,$$

by substitution, from

$$(8)\quad h = \pi \frac{1}{l_1} [l_1 H_2 + \lambda (H_1 - H_2)]$$

from

$$(9)\quad h' = \pi \frac{1}{l_1} [l_1 H_2' + \lambda (H_1' - H_2')].$$

But

$$H_1' = H_1 - B B' = H_1 - O B \, tg\, a = H_1 - (l_1 - \lambda) tg\, a,$$
$$H_2' = H_2 + \lambda \, tg\, a,$$

hence from (9)

$$h' = \pi \frac{1}{l_1} [l_1 (H_2 + \lambda\, tg\, a) + \lambda (H_1 - (l_1 - \lambda)\, tg\, a - H_2 - \lambda\, tg\, a\,]$$
$$= \pi \frac{1}{l_1} [l_1 H_2 + l_1 \lambda\, tg\, a + \lambda H_1 - l_1 \lambda\, tg\, a + \lambda^2\, tg\, a - H_2 \lambda - \lambda_2\, tg\, a]$$
$$= \pi \frac{1}{l_1} [l_1 H_2 + \lambda (H_1 - H_2)] = h.$$

The new method then, in its application to an oblique section normal to the plane of symmetry of a rectangular column of masonry, whose upper surface is oblique, but normal to two parallel faces, obtains an exact expression for the unit pressure in the direction of the greatest compression. This method in general gives correct results for each rectangular section, so long as the resultant of the pressures lies in a plane of symmetry to the section, and the Navierian hypothesis is admissible. For example, let us take a joint of an arch, to which the resultant of pressures, according to Mery's theory, is oblique. That part of the arch which lies between the crown and the joint, and the masonry above, have caused the pressures to which the resultant is due. These pressures are themselves determinate functions of the magnitude and direction of the resultant, as well as of the point of application. For, by Navier's hypothesis and by equation (1), it follows that the greatest contraction at every point of the joint, and the element pressure caused by it, are proportional to the distance, measured parallel to the resultant, between the point and a joint at an infinitesimal distance. Parallel forces acting upon given points of a plane are fully determined, if their resultant is known in magnitude and direction.

If this is given, we consider parallels to the resultant of the pressures as drawn through each edge of the given joint, and regard these as the edges of a column of masonry, in which gravity acts parallel to the edges; then cut it off by an oblique plane parallel to the plane of symmetry, and assume that the given sectional plane is subjected to the pressure due to the weight of the column. Putting H_1 and H_2 for the greatest and least edges, q for the current unit weight, the weight of the column is $\frac{H_1 + H_2}{2} q$. If l_1 is the orthogonal projection of the sectional length upon the rectangular section of the column, the distance of the centre of gravity of the column from the face whose height is H_1 is found by (6) to be

$$\frac{H_1 + 2H_2}{3(H_1 + H_2)} l_1$$

and if R is the resultant of the pressures to which the joint is subjected, and G its distance from the face whose attitude is H_1 we have

$$R = \frac{H_1 + H_2}{2} q \quad . \quad . \quad . \quad (10)$$

and

$$G = \frac{H_1 + 2H_2}{3(H_1 + H_2)} l_1 \quad . \quad . \quad . \quad (11)$$

and from these equations the unknown quantities H_1 and H_2 can be found. Hence, in general there is a column with the determined altitudes H_1 and H_2, which by its weight would exert upon the given joint a pressure whose resultant would be just as great as that of the pressures to which the arch is actually subjected.

The Navierian hypothesis is also applicable to the joint if it is considered as belonging to the column. Consequently, the elementary pressures upon the joint are expressed as functions of the magnitude and direction of the resultant and of the position of the point of application. The point of application of the elementary pressures in the joint is the same in the arch as in the column; the resultant is also the same; consequently the elementary pressures must be equal. Hence, it follows that the pressure in the arch joint can be determined upon the hypothesis that it is caused by the weight of the column, and that the results obtained from the consideration of the pressures in a section of a column of masonry are applicable to the arch joint.

Hence, if we wish to calculate the unit pressure at any point in a rectangular section of masonry by a force not normal

to this section, but lying in a plane bisecting two parallel sides of the sectional plane, and normal to it, we put instead of this force, the normal force whose orthogonal projection is equal to it, and proceed as if this force were normal to the cutting plane.

From equations (10) and (11)

$$H_1 = \frac{2R}{q\,l_1}(2l_1 - 3G) \text{ and } H_2 = \frac{2R}{q\,l_1}(3G - l_1)$$

and as H_1 or H_2 may either be negative, and since

$$2l - 3G > 0 \text{ or } G < {}^2/_3\,l_1,$$
$$3G - l_1 > 0 \text{ or } G < {}^1/_3\,l_1$$

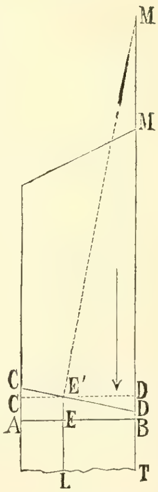
they lie between $\frac{}{3}l_1$ and $\frac{2}{3}l_1$.

In Fig. 1, the resultant of weight which passes through the centre of gravity of A B N M, cannot be distant from the longer of the two sides H_1 and H_2 less than $\frac{1}{3}\,l_1$ or more than $\frac{2}{3}\,l_1$; if one side is 0 the distance is $\frac{1}{3}\,l_1$. But the column may be subject to external vertical pressures upon its upper surface, which, combined with the weight above, A B, give a resultant R distant less than $\frac{1}{3}\,l_1$ from B M. If the external forces are of such a nature as to admit Navier's hypothesis, the section C D, which is under action of external forces and of gravity at the infinitesimal distance A C^1=B C^1 from A B, will cut the latter in a straight line whose trace is E^1. For if D were entirely below C^1 D^1 the resultant of the molecular reactions would pass through the centre of gravity of the trapezium lying between the lines, and therefore would not have an opposite direction to the resultant of the weight of the column and the external forces, which lies at a distance less than $\frac{1}{3}\,l^1$ from B M; while there is always equilibrium if C D cuts the line C^1 D^1, provided the limits of elasticity are not passed.

If the material can equally well resist compression or tension, the resultant of the tensile forces would be proportional to the triangle C E^1 C^1; that of the forces of compression, to the triangle D E^1 D^1. Since they maintain the equilibrium of the resultant R, and must pass through the centre of gravity of these triangles, their magnitude is easily determined, as well as the equations necessary to determine the line C D; that is, the amount of compression or extension at any point of the line A B. If it is assumed (a safer hypothesis if pressure is to act upon damp mortar) that the material has only to resist compression, the triangle C E^1 C^1 would represent only a parting of the same kind as happens at the foot of an arch upon the sudden displacement above. The triangle, D E^1 D^1 represents the molecular action of contraction while its surface is proportional to R and its centre of gravity lies in the direction of R. An obliquely-cut column may also be conceived whose upper portion exerts a weight equal to R on A B.

The part of the section A B, of which the trace is A E, experiences no pressure; the part E B is under the same relations as if it belonged to the column L T E M^1; hence the contraction at any place can be calculated as in the case of the last column, and the new method may be applied if the resultant is not normal to the section.

FIG. 4.



If G does not lie within the limits before assigned, the pressures in the section may be still considered as under the pressure due to a column, L T E M^1, Fig. 5, and the calculation may be made by application of the new method. The portion in question lies between that one of the sides standing perpendicular to the plane of symmetry which lies nearest the resultant, and a parallel to it drawn at the distance $\frac{3G}{\cos a}$, which is also the lowest side of the oblique cutting section of the column. The altitude, H_1, which is given by

$$H_1 = \frac{2\,R}{3\,G\,\varepsilon\,\pi},$$

if π is the weight of a unit volume of the column and e the breadth of the section. It is obvious that the column thus determined has its centre of gravity in the direction of the resultant of pressure, and that its weight, P, corresponds to this resultant:

$$P = 3\,G\,\varepsilon\,\frac{H_1}{2}\,\pi = \frac{3\,G\,e\,\pi}{2}\cdot\frac{2\,R}{3\,G\,\varepsilon\,\pi} = R$$

H_1 in this case is always positive.

It is consequently proved that the new method is applicable under the above conditions. In cases in which G does not lie between $\frac{1}{3}\,l_1$ and $\frac{2}{3}\,l_1$ and the section is reduced to $\frac{3\,G}{\cos\,a}$ (measured from the side lying nearest the point of application of the resultant), the calculation of the unit pressure in the direction of the maximum contraction is made by means of the resultant R, if this is normal to the section; but if it is oblique, the magnitude $\frac{R}{\cos\,a}$ must be used.

THE GAUGE FOR "THE RAILWAYS OF THE FUTURE."*

The object of this paper is to show in what manner, and to some extent in what degree, the cost of the construction and maintenance of railways is affected by the gauge on which they are built; and by what means it would be possible at once to increase the dividends of shareholders, and to extend the countless advantages railways afford to all parts of the habitable globe, however thinly peopled or unproductive. It will be in the recollection of many that the question of the proper gauge for railways was once a matter of earnest dispute; and that what was called the "Battle of the Gauges," as between broad and narrow, was fought with desperate vigor and with no decided result. Each party of belligerents retired from the contest with heavy pecuniary loss; but neither would allow that the other had been the victor. The result was that the construction of each gauge was pushed forward by those who were interested in it; and thus it befell that a broad gauge line was carried into the northern districts, from which its subsequent removal was the best proof that it ought never to have been taken there.

Although the controversy to which I have referred was conducted with singular ability, and at a very lavish expenditure of the money of confiding shareholders, it is curious to observe that those concerned in it seem never to have taken into account the relative *economy* of the plans that they respectively advocated. The consideration of this most important element in the question would have thrown upon it a totally new light. But the very word was at that time unknown to the railway world, and the thing which the word signifies has scarcely yet gained its due share of consideration. Had it done so, the present paper would have been unnecessary; for it would have been proved, years ago, that while a narrow gauge is infinitely less costly than a broader one, its capabilities in respect of power and speed are fully equal to the wants of the country. If this had been known, we should not have seen, as at present, large districts deprived of all prospects of railway accommodation; and thousands of shareholders regretting the loss of that return to which their expenditure has fairly entitled them.

Apart from the important question of economy, the carrying capacity of gauges less than 4 ft. $8\frac{1}{2}$ in. has never yet been considered in its true light. It has been hastily assumed that a line of narrower gauge than this would be very limited, both in its carrying power, and also as regards the speed at which trains could be run; and it has been argued that the saving in cost would be too small to render it desirable to make a change. It is not my purpose to advocate such a change in Great Britain, where a 4 ft. $8\frac{1}{2}$ in. gauge is actually established and at work, and where it affords the necessary facilities for the speeds of 60 or 70 miles per hour that are actually run over it; but only to take the conditions of English railway traffic as an illustration of my general arguments. At the same time it must not be forgotten that these conditions could be in some degree modified in

* A Paper read before the British Association at Liverpool.

the direction of economy by the employment of a new and lighter description of rolling stock. It is known and everywhere admitted that the proportion of non-paying to paying weight in passenger trains is as much as 29 to 1, and in goods trains, exclusive of minerals, as much as 7 to 1. This terrible disproportion is partly due to the system of management pursued; but in a far greater degree to the gauge. The dead-weight of trains conveying either passengers or goods is in direct proportion to the gauge on which they run; or, in other words, the proportion of non-paying to paying weight (as far as this is independent of management) is increased exactly as the rails are farther apart, because a ton of materials disposed upon a narrow gauge is stronger as regards its carrying power than the same weight when spread out over a wider basis. In proof of this proposition I need only cite the case of the Festiniog railway, with its gauge of 1 ft. 11½ in. The wagons used upon it for carrying timber weigh only 12 cwt., and they frequently carry a load of over 3½ tons at a speed of 12 miles an hour. In other words, these wagons carry as much as six times their own weight, whilst the best wagons on the ordinary English narrow gauge do not carry as much as twice their own weight.

The good management of the London and Northwestern Railway is so universally admitted, that it will seem almost presumptuous to select this line as an illustration of the faults of the existing system. I have, however, selected it, because its management is such that its shortcomings must be wholly due to its construction; and I shall proceed to show that, if its gauge were 3 ft. instead of 4 ft. 8½ in., its goods traffic could be hauled at half the present cost, with half the present motive power, and in such a way as to reduce the present tonnage over the road by one half, and to remove the necessity for the heavy expense that is now being incurred in the construction of a third line of rails. I am perfectly prepared for the incredulity with which these statements will at first be received; but I shall prove their correctness by figures that cannot err. The writer who originally said that a train weight of thirty tons had to be set in motion for every ton of passengers carried was at first ridiculed for his pains; but after a time, and when people came to inquire into the matter, it was found that his statement was absolutely correct, insomuch that it is now universally received and admitted. In like manner the facts about the goods traffic require only to be investigated; and every one possessed of common sense will find it easy to understand them.

The goods and mineral traffic on the London and Northwestern Railway for a single year amount to about 15,000,000 tons. I will assume that 5,000,000 out of these 15,000,000 tons are minerals, consisting chiefly of coal; and I will deal only with the 10,000,000 tons of goods which are left as the net residue of the year's carrying. It has been proved that the proportion of non-paying to paying weight is about 7 tons to 1 ton; and this would give 70,000,000 tons of rolling weight employed to carry the 10,000,000 tons of paying load. In order to avoid all risk of exaggeration, I will assume the dead weight to be only as 4 tons to 1, which reduc s from 70,000,000 to 40,000,000 tons the weight of the wagons employed to carry the 10,000,000 tons of paying load. The whole gross weight hauled by the locomotives will then be 50,000,000 tons, at an average speed of 25 miles an hour.

The earnings for the goods traffic on this line are 6s. 3d. per train mile; which, at an average rate all round of 1½d. per ton per mile, would give about 50 tons as the paying weight, and 255 tons as the gross weight hauled per train mile. Dividing this 255 tons into the 50,000,000 gives 196,089 trains; which, being divided by the 313 working days of a year, give 626 merchandise trains, over all parts of the Northwestern Railway, in the 24 hours.

The Company's balance-sheet shows that each net ton produces about 4s. 8d. (including minerals, but as the net amount earned per train mile in the merchandise and mineral traffic may be taken as averaging nearly the same, this does not vitiate the argument), which, at 1½d. per ton per mile, makes the average distance traversed by each ton to be about 38 miles; so that as each ton of the total weight hauled runs 38 miles, and the entire length of line worked is 1,432 miles, it follows that there must be on an average 37 merchandise trains distributed over the total length. This number, divided into the total number of trains per day of 24

hours, gives an average of over 17 trains per day running on each mile of the line. My object in bringing the figures to this point is to show that, although at first sight the number, 626 trains per day, looks large, yet, when divided over the entire line, it is comparatively small.

Having arrived at this conclusion, we are in a position to see how it would affect the question if the gauge of the line were 3 ft. instead of 4 ft. $8\frac{1}{2}$ in. In the first place, the same or a greater speed could be maintained, say up to 35 or 40 miles an hour. I mention the speed here because I am dealing with goods trains only. Of course when passenger trains are considered, the element of speed tells largely in favor of the broad (*i. e.*, 4 ft. $8\frac{1}{2}$ in.) gauge; but this has been already admitted. My argument is only intended to show what a 3-ft. gauge is capable of accomplishing in the way of duty, up to a speed of 40 miles an hour; a speed which on such a gauge can only be obtained by the employment of the double bogie engines.

The speeds in each case being therefore equal, the next point to examine is the result of carrying on the narrow gauge. The proportion of non-paying to paying load has been taken at 4 to 1 on the broad gauge, although it has proved largely in excess of this. The wagons employed average 4 tons in weight, so that on this reckoning each wagon carries 1 ton for every mile it runs. It would be well to remember here that I am dealing with things as they are, not as they might be.

The wagons for a line of 3-ft. gauge weigh each 1 ton, and carry a maximum load of 3 tons. Supposing that the same number of wagons and trains were run on the narrow gauge as on the broad, it follows that the average 1 ton of merchandise now carried would easily be taken in a wagon weighing 1 ton instead of 4 tons, and that the gross load passing over the line for 1 year would be only 20,000,000 tons instead of 50,000,000; whilst the same amount of paying weight would be carried in either case. That is, the small wagons, which are capable of carrying 3 times the weight of goods now actually carried in a 4-ton wagon, would only have to carry $\frac{1}{3}$ of that quantity, and would produce the same paying load as the heavier wagons; thus, instead of 50,000,000 of tons travelling over the line, there would only be 20,000,000, and, as the haulage cost is precisely the same whether the tons hauled consist of paying or of non-paying load, it follows that this expense would be reduced to $\frac{2}{5}$ of what it now is. We must also consider the enormous saving to the permanent way, which would have to bear the friction and weight of only 20,000,000 tons in the place of 50,000,000. If we assume the same number of trains to run per day, the weight of each would be reduced from 255 tons to 102 tons; or, if the same gross weight of train was employed, the number of trains per day would be reduced from 626 to 250. If there should be sufficient traffic to load the narrow-gauge wagons in such a way as to require the same number and weight of trains that are now worked, the result would be that, without increasing by one penny the cost of haulage and of the permanent way expenses, the 3-ft. gauge would carry a paying load of 25,000,000 tons as against the 10,000,000 now carried. Here, then, we have established the fact that, so far as capacity goes, the narrow gauge is superior to the broad one. The former can produce 25,000,000 net out of a gross tonnage of 50,000,000; whilst the latter, to produce the same result, if continued to be worked as it now is, would require that 125,000,000 tons should be hauled, and that at an increased cost in the same proportion of 125,000,000 to 50,000,000.

It may occur to some of my hearers to ask at this stage whether locomotives can be built to haul large train loads on a 3-ft. gauge at the same speeds at which such loads are now taken on the broad gauge—my answer to this is decidedly "Yes."

The Fairlie double bogie engine cannot only be made to haul trains fully as heavy and at the same speeds as those now taken on the broad gauge; but it will do this on what is termed a light railway, with rails that shall not be required to exceed 50 lbs. to the yard, and that shall be fairly worn out, instead of being crushed and ground out as the 84 lbs. rails are under the present system.

It will be seen from this that a very large and important saving could be effected on the London and North-western Railway, if its gauge were 3 ft. instead of 4 ft. $8\frac{1}{2}$ in., without changing in the least degree its present system of management; and that this saving, di-

vided between the public and the shareholders, would largely reduce the tariffs to the one, whilst it as largely increased the dividends to the other.

Before entering on another example of the advantages of the narrow gauge, it will perhaps be well to explain why it is that the average paying-load now carried on the Northwestern Railway bears so small a proportion to the weight of the wagons employed in carrying it. The reason is obvious enough. The railway covers a very large area of country, and penetrates into districts from which there is a very unequal traffic; so that there must be a large average of empty wagons passing from one place to another in order to accommodate this traffic. It is impossible to find the same tonnage leaving a station that enters it. There is also great competition for the traffic; since most, if not all, of the large towns touched by this railway are also supplied by one or more lines belonging to other companies, and the inhabitants, having a choice, take care to avail themselves of it by fighting one company against the other. The result is, that each company tries to outbid its neighbor, not only in rates of charge, but also in affording the greatest despatch. This practically amounts to a competition as to which company shall run the greatest number of half filled or empty wagons.

Suppose, for example, that a person delivers a bundle of chairs, or a quantity of any goods, at a station, to be forwarded to some other station. The station-master cannot keep the chairs or other goods until he has a wagon load going to the same place; but must despatch them forthwith, perhaps alone in a wagon that ought to carry 10 times the quantity. But whatever may be the explanation of the small proportion of paying to non-paying load, the fact must in any case tell in favor of the narrow gauge. Suppose even that the wagons always ran empty one-half their time. Take the case of coal wagons, which run full only one way, and return empty. The narrow gauge still has the advantage, for they are only 1 ton wagons that run empty instead of being 4 ton wagons. In the case of the bundle of chairs there would only be the actual weight of the chairs added to that of the 1 ton wagon, instead of to the weight of a 4 ton wagon; so that, however the matter is looked at, it will always be found that the advantages on the score of economy are enormously in favor of light narrow gauge railways.

In India the competition between companies does not exist, and it is possible to detain goods at stations until a maximum quantity is obtained for transport. Time is there of little importance, and hence it has been urged that under such circumstances a large gauge and large wagons are the best, in order that it may be practicable to run a small number of heavy trains per day.

It is impossible to conceive an argument more fallacious than this; and its employment has saddled India with the commencement of a system of railways extravagantly beyond the requirements of the country for the next hundred years, or even for ever.

I have just shown that a 3-ft gauge-line can carry, without an additional shilling for haulage, $2\frac{1}{2}$ times as many tons as are now carried over the 4 ft. $8\frac{1}{2}$ in. gauge of the Northwestern Railway. Whence then arises the necessity for constructing the Indian Railways on a 5 ft. 6 in. gauge? especially when it is remembered that the total goods traffic worked over the whole of them does not amount to a sixth part of that now carried on the Northwestern Line alone.

Taking the case of the East India Railway as being the Northwestern of India, let us see how the absence of competition and the 5 ft. 6 in. gauge affect the question of transport. The number of net tons hauled over the line for the year ending 1869, was 938,629, in 32,490 trains; amounting to about 29 tons per train. The average number of wagons composing a train is taken at 25, of 6 tons each; which gives 150 tons of train or 29 tons of freight, or a proportion of over 5 tons of dead to 1 ton of paying load. It will be seen that, notwithstanding the absence of competition, and with everything to favor the working of the line, the actual dead weight is over 5 tons to 1 ton. If, on the other hand, the gauge had been 3 ft. instead of 5 ft. 6 in., the dead weight, under the same management, would have been reduced from 5 to 1, to $1\frac{1}{4}$ to 1. Let us imagine the saving that this change would effect in fuel alone; considering that less than one-fourth of the tonnage now hauled would afford precisely the

same accommodation to the traffic that now exists, and would produce the same paying result. It surely does not require a philosopher to see that the narrow gauge is infinitely superior in every respect even to the 4 ft. 8½ in. gauge, and it ought to be engraved on the mind of every engineer that *every inch added to the width of a gauge beyond what is absolutely necessary* for the traffic, *adds to the cost of construction, increases the proportion of dead weight, increases the cost of working*, and in consequence *increases the tariffs to the public*, and by so much *reduces the useful effect of the railway*. Let us suppose for one moment that the conditions of the cost of construction in the two instances were reversed, and that a 3 ft. gauge line would cost twice as much to make as a 5 ft. 6 in. gauge, even in such a case the difference in the cost of working each ton of goods would be so enormous that the narrow gauge would be by far the cheapest of the two in the end. It is unnecessary to say that the cost of constructing a railway is nearly as the width of its gauge ; in very rough countries the narrow guage will be greatly less than the proportion to its width, whilst in flat level ground the proportion will be more ; but, taking the average (excluding rolling stock, fencing, stations, and telegraphs), the cost will be found to vary as the gauge. The advocates of the 5 ft. 6 in. gauge, not content with the burthen which they have imposed upon India, are striving to impose a similar burthen upon our Colonies, and in too many instances they have actually succeeded. The Colony of Victoria, for example, has been provided with a system of 5 ft. 6 in. gauge railways, which are so magnificent and costly that they charge the Colonial revenue with a trifling deficit of £30,000 per annum.

Tasmania, under the same management, has been saddled with a railway of 5 ft. 3 in. gauge. There are other places similarly situated, but to mention them all would prolong this paper beyond its proper limits. I have shown sufficient evidence to prove what I said at the commencement ; and, through the medium of this great Association, I desire to inform the inhabitants of countries in which railways are required, how these can be obtained cheaply and efficiently. In moderately temperate climates, gauges of 2 ft. 6 in. will be found ample for any traffic in any part of the world, and will sustain a speed of 30 miles an hour ; while 3 ft. is sufficient for either very hot or very cold climates, and will sustain a speed of forty miles an hour.

Railways can be made cheaply, and at the same time, to be thoroughly efficient ; and those who aver to the contrary are, in fact, enemies to progress and to civilization. There is no country too poor to have railways sufficient for its requirements ; and railways furnish the cheapest possible mode of transport when they are not borne down by the result of that incompetence and extravagance which we so often see associated together. I regard it as the duty of every man in the old country to assist those in the new by pointing out how they may benefit by our dear-bought experience, and may avoid the pitfalls into which only too many of our Railway Shareholders have fallen.

The present railways in India, although doubtless valuable for military purposes, have cost about £20,000 per mile. The average rate per ton paid on the East Indian Railway is 2¼d. per ton per mile. It may be fairly questioned how far these lines are boons to the inhabitants, who are called upon to pay taxes to cover the heavy annual interest on the cost, as well as to pay the high tariff of rates mentioned above. In any Indian extensions it should clearly be our aim to satisfy the natives, and to develop traffic at their hands. How different would the results have been, even now, if the lines had cost £5,000 instead of £20,000 per mile, and if the tariff of rates had been ½d. per ton per mile instead of 2¼d. Not only would this have been practicable if the narrow gauge had been adopted, but the charge for the conveyance of salt, one of the first necessaries of life in the country, need not have exceeded ¼d. per ton per mile.

I cannot close this paper without some reference to a matter that is now part of history, and that serves as an admirable illustration of the manner in which self-interest, or even mere conservatism, may render men blind to the most obvious propositions. There are some whose whole desire it seems to be to rest in the paths that they have become accustomed to tread ; and whose instincts lead them at once to turn and rend any one that proposes a change. In January last my

presence was hurriedly required in St. Petersburg by the Russian Minister of Public Works, with reference to the subject of the Fairlie system of railways, to which attention had been called by the very able articles upon the "Railway Problem," which appeared in "The Times" on the 19th, 20th, and 21st October, 1869. (A reprint of these articles will be found on the table.) His Excellency the Minister required me to give a short distinct account of the advantages claimed for my system. I replied, that by the adoption of that system railways could be made at a cost of little over one-half the sum required to construct them on the ordinary plan; so that it would be possible to give nearly *two* miles for the sum now expended upon one. That these lines, when finished and equipped, would possess a carrying capacity equal to, if not greater than that of those on the old system. In other words, they should be capable of carrying as many passengers and tons of goods in twenty-four hours as the best lines now existing; and that this should be done at a reduced cost, independently of the reduced wear and tear to the permanent way, and of the value of the increased life of the rails. His Excellency observed, that if only a portion of this could be accomplished, it would be a great thing for Russia, and that the matter should be at once inquired into. Not many days elapsed before an Imperial Commission, composed of a number of the most noted scientific men in Russia, and presided over by His Excellency the Count Alexis Bobrinskoy, private Attache to his Imperial Majesty the Emperor, was instructed to come to this country and to investigate the correctness of what I had asserted. Early in February the Commission arrived in London, and after a thorough examination of the question in all its theoretical bearings, it was resolved to put it to some practical tests. The Council of India, the Board of Trade, Norway, France, and other countries sent their representative men to be present on the occasion, as it was felt that what was good for Russia would be equally good for the countries I have mentioned. His Grace the Duke of Sutherland, always anxious to promote any system that will most largely benefit mankind, and having already a large section of railways of his own, built expressly to improve the condition of his tenantry, joined the party, and took a most active interest in all the proceedings. The results of the experiments then made are pretty well known, and any who may not be acquainted with them will find printed records of them on the table.

The Commission returned to Russia, and sent in its report to the effect that I had fully proved the correctness of all my assertions. This was in March, and in April a railway of fifty versts, on the new system, was ordered by his Majesty the Emperor to be constructed, and to be opened in November next. The locomotives for this railway may be seen any day during the next month at the establishment of Messrs. Sharp, Stewart, and Co., Manchester. The new system has also been adopted for working some of the old lines, and the stock for the Tamboff Saratoff Railway, the Great Russian, and others, may be seen under construction at the same establishment.

The members of the Council of India were so struck with the accounts of the system, that the Home Engineers of the several Indian railways were requested to report to their respective Boards their opinions on the applicability of a new narrow gauge for India. I have seen several of these reports, the whole of which are unanimous in their opposition to any improvement, or to any interference with the system under which the writers have lived, and moved, and had their being; but in only one of them is there any argument that requires a moment's notice. Mr. Hawkshaw, in his Report to the Directors of the Eastern Bengal Railway, urges that, since those who are in favor of a narrow gauge argue upon the basis of a light rolling stock, the same basis should also be taken by the advocates of a broad gauge. Were it not for this attempt at reasoning, and also for the fact that Mr. Bidder very fiercely attacks both me and my system, I should have left the reports wholly without mention. But I think it is worth while to reply to Mr. Hawkshaw, and also to place on record that Mr. Bidder has evidently never seen my system, although often invited to do so; and that he has based his condemnation of it upon an utterly incorrect description, both as regards principles and details.

The claim to calculate for broad gauge lines on the basis of lighter rolling stock,

is practically an admission that grave errors have been made in designing that which is now in use, and which it is proposed theoretically to set aside while the question of gauge is under discussion. But however Mr. Hawkshaw may build his stock in the future, he cannot possibly build it so light and capable of doing so much duty for the broad as for the narrow gauge. His argument is a complete confession of the mistakes made under the old regime ; whilst at the same time it is an attempt to extinguish the general wish to inquire into the merits of the new. It is asking to be forgiven for the past, with a promise to do better in the future,—or to do anything rather than permit clients to go to a new school.

It is a sad incident in the great history of human error when we thus find men led into such mistakes as these by their anxiety to resist innovation. How different would be the course of invention, how smooth the path of improvement, what years of anxious labor would be saved to many of us, if such men would lay aside all rivalries, and would bring their helping hands to the good work of progress.

THE SOLAR ENGINE.

By Captain JOHN ERICSSON

From "Engineering."

On grounds which will appear hereafter, it is not my intention at present to enter on a minute description of the solar engine. I feel called upon, however, in order to remove prevailing erroneous impressions on the subject, to state briefly the general features of my scheme. At the same time, let it be understood that the solar engine is not intended as a competitor with the steam-engine, where coal can be obtained ; nor is it proposed, in the first instance, to erect this motor where there is not continuous sunshine.

The accompanying illustration, which derives its chief interest from the fact that it represents a piece of mechanism actuated by the direct agency of solar heat, is copied from a photograph of a small solar engine just completed, intended as a present to the French Academy of Sciences. Apart from being a motor, this engine has been designed to operate as a meter for registering the volume of steam generated by the concentrated heat of a sunbeam of a given section. Regarded as a steam meter, it is important, as it verifies the results of previous experiments and previous calculations based on the number of units of heat developed in evaporating a certain weight of water in a given time. Engineers will not fail to notice the unusual proportions of the working parts, nor will they fail to appreciate the object in view, that of reducing the friction to a minimum—an indispensable condition in a meter. The entire mechanism being shown with perfect distinctness, it is only necessary to explain that the square pedestal which supports the steam cylinder ($4\frac{1}{2}$ in. in diameter), the beam centre, and the crank shaft, conceals a surface condenser.

Under a clear sun the engine which our illustration represents runs, with perfect uniformity, at a fixed rate of 240 revolutions per minute, consuming at this rate only part of the steam furnished by the solar steam generator, now temporarily employed, belonging to an engine of greater dimensions constructed some time ago. With reference to ascertaining the amount of mechanical power developed by the solar engines, engineers need scarcely be reminded that, by dispensing with a vacuum, the atmospheric resistance and back pressure exerted against the pistons furnish accurate means for measuring the dynamic force transmitted by sunbeams of definite sections.

Plans and descriptions of the mechanism by which the sun's radiant heat is concentrated, and of the steam generator which receives the concentrated heat, I shall be compelled, for some time, to withhold from publication. Experienced professional men will appreciate the motive, that of preventing enterprising persons from procuring patents for *modifications*. In connection with the course thus deemed necessary, it will be proper to mention that I have in several instances, notably in the case of the screw propeller and the caloric engine, been prevented from perfecting my invention in consequence of

conflicting privileges having in the mean time been granted to others.

Regarding the solar engine, I avail myself of this opportunity to say that I shall not apply for any patent rights, and that it is my intention to devote the balance of my professional life almost exclusively to its completion. Hence my anxiety to guard against legal obstructions being interposed before perfection of detail shall have been measurably attained. Within a few years the entire engineering community of both hemispheres will be invited to take the matter in hand. In the meantime let us hope that no exclusive privileges may be granted tending to throw obstacles in the way of an unrestricted manufacture and introduction of the new motor wherever it may be applicable.

The foregoing having introduced the subject, let us now enter upon a cursory examination of the merits of the solar engine. The several experiments that have been made show that the mechanism adopted for concentrating the sun's radiant heat abstracts, on an average, during nine hours a day, for all latitudes between the equator and 45 deg., fully 3.5 units of heat per minute for each square foot of area presented perpendicularly to the sun's rays. A unit of heat being equivalent to 772 foot-pounds, it will be perceived that, theoretically, a dynamic energy of 2702 foot-pounds is transmitted by the radiant heat, per minute, for each square foot; hence 270,200 foot-pounds for an area of 10 ft. square. If we divide this sum by the adopted standard of 33,000, we ascertain that 100 squre feet of surface exposed to the solar rays develop continuously 8.2 horse power during nine hours a day, within the limits of latitude before mentioned. But engineers are well aware that the whole dynamic energy of heat cannot be utilized in practice by any engine or mechanical combination whatever, nor at all approached; hence I have assumed, in order not to overrate the capability of the new system, that a solar engine of 1-horse power demands the concentration of solar heat from an area of 10 ft. square. On this basis I will now proceed to show that those regions of the earth which suffer from an excess of solar heat will ultimately derive benefits resulting from an unlimited command of motive power which will, to a great extent, compensate for evils hitherto supposed not to be counterbalanced by any good. Before entering on this task of estimating the results of utilizing sun power, it will be well to scrutinize, as closely as we can, the mechanical devices by means of which we propose to avail ourselves of the fuel contained in that great store-house from whence it may be obtained free of cost and transportation. The solar engine, we have seen, is composed of three distinct parts. The engine, the steam generator, and the mechanism by means of which the feeble intensity of the sun's rays is augmented to such a degree that the resulting temperature will exceed that of the lowest pressure of steam admissible in an efficient engine. As to the motor itself, it suffices to say, that it is essentially a modern steam engine utilizing, to the fullest extent, the mechanical energy of the steam generated by the concentrated solar rays. Regarding the steam generator, it will only be necessary to state that it is not exposed to the action of fire, clinkers, or soot, and therefore can only suffer from the slow action of ordinary oxidation. We have lastly to consider the efficiency of the mechanism by means of which the solar heat is concentrated and the temperature raised above that of the water in the steam generator. Regarding this mechanism—concentration apparatus it may appropriately be termed—it will be asked: is it costly? is it heavy and bulky so as to render transportation difficult? and finally the question will be put, is it liable to derangement and expensive to keep in order? I will answer these questions in the same order in which they have been presented. The cost is moderate. The weight is small—indeed lightness is the most notable peculiarity of the concentration apparatus. As to bulk, this apparatus is composed of small parts readily put together. Regarding durability, the fact need only be pointed out that certain metals however thin, if kept dry, may be exposed to the sun's rays during an indefinite length of time without appreciable deterioration; hence, unlike the furnaces of steam boilers, which soon become unserviceable, structures protected as the concentration apparatus is, by thin metallic plates, cannot be rendered unserviceable from the mere action of the sun's rays. Another question will be asked, whether the solar engine will answer as

well on a large as it does on a small scale? The following reply will effectually dispose of this pregnant query. It is not necessary, nor intended, to enlarge in future, the size of the apparatus by means of which the solar intensity has been successfully concentrated and the temperature sufficiently elevated to generate steam for the engines which have been built. The maximum size adopted has been adequate to utilize the radiant heat of a sunbeam of 35 square feet section. The employment of an increased number of such structures will therefore be resorted when greater power is wanted, as we increase the number of hands when we desire to perform an additional amount of work. The motor itself, the steam cylinder and other parts, will obviously be proportioned as at present with reference to the pressure of steam employed and the work to be done.

Agreeable to our introductory remarks, it is not proposed in the first instance, to apply solar engines in places where there is not steady sunshine. The isolated districts of the earth's surface suffering from an excess of solar heat being very numerous, our space only admits of a glance at the sunburnt continents. An examination of the extent of these will show that the field for the solar engine, even with the proposed restriction, is not very contracted. There is a rainless region extending from the northwest coast of Africa to Mongolia, 9000 miles in length, and nearly 1000 miles wide. Besides the Northern African deserts, this region includes the southern coast of the Mediterranean east of the Gulf of Cabes, Upper Egypt, the eastern and part of the western coast of the Red Sea, part of Syria, the eastern part of the countries watered by the Euphrates and Tigris, Eastern Arabia, the greater part of Persia, the extreme western part of China, Tibet, and lastly, Mongolia. In the western hemisphere, Lower California, the table-land of Mexico and Guatemala, and the west coast of South America, for a distance of more than 2000 miles, suffer from continuous intense radiant heat.

Computations of the solar energy wasted on the vast areas thus specified would present an amount of dynamic force almost beyond conception. Let us, therefore, merely estimate the mechanical force that would result from utilizing the solar heat on a strip of land, a single mile in width, along the rainless western coast of America; the southern coast of the Mediterranean before refered to; both sides of the alluvial plain of the Nile in Upper Eygpt; both sides of the Euphrates and Tigris for a distance of 400 miles above the Persian Gulf; and, finally, a strip one mile wide along the rainless portions of the shores of the Red Sea, before pointed out. The aggregate length of these strips of land, selected on account of being accessible by water communication, far exceeds 8,000 miles. Adopting this length and a width of one mile as a basis for computation, it will be seen that the assumed narrow belt of the sunburnt continents covers 223,000 millions of square feet. Dividing this by the area necessary to produce 1-horse power, we learn that 22,300,000 solar engines each of 100-horse power, could be kept in constant operation, nine hours a day, by utilizing only that heat which is now wasted on a very small fraction of the land extending along some of the water fronts of the sunburnt regions of the earth.

It will be said that these extravagant figures are devoid of practical significance. Due consideration, however, cannot fail to convince us that the gradual exhaustion of the coal fields will inevitably cause great changes in regard to international relations, in favor of those countries which are in possession of continuous sun power. Upper Egypt, for instance, will, in the course of time, derive signal advantage, and attain a high political position, on account of her perpetual sunshine and the consequent command of unlimited motive force. The time will come when Europe must stop her mills for the want of coal. Upper Egypt, then, with her never ceasing sun power, will invite the European manufacturer to remove his machinery and erect his mills on the firm ground along the sides of the alluvial plain of the Nile, where sufficient power can be obtained to enable him to run more spindles than a hundred Manchesters.

I reserve for another occasion, the consideration of the important question: To what extent can the irregular sunshine of Europe be rendered available in producing a regular motor, by the expedient of alternately accumulating and drawing upon reserved force?

PNEUMATIC TRANSMISSION THROUGH TUNNELS AND PIPES.*

By ROBERT SABINE.

From "Engineering."

Some months since I had occasion to assist in designing the extension of a pneumatic despatch line in which some heavy gradients were, from considerations of economy and the peculiar nature of the land, unavoidable. It became, therefore, necessary to ascertain by calculation the steepest gradient which we could venture to employ, so as to obtain a sufficient carrying capacity in the new section of the line under given conditions of engine power and of length. On referring for information to text-books and the papers of various authorities on the velocity of gases in pipes, I found that almost every one of them gave a different formula, so that by some a very high, and by others a very low rate of transmission was promised under identically the same circumstances. I was further disappointed at failing to find in any of the ready-made formulæ which I was in possession of that the weight and friction of a piston or carrier were taken into account.

The conditions of motion in a pipe through which gas is simply blown—passing in at one end and out at the other—are different from those of a tube through which the gas has to propel a piston. When the gas alone passes through, it expands gradually and regularly in the whole length of the tube, from the higher pressure at one end to the lower pressure at the other. But when a carrier, whose motion offers considerable resistance, is inserted, it is driven forwards with a mean velocity corresponding to that with which the air at the higher pressure is introduced behind it, or that at the lower is exhausted in front of it. For if the compressed air were introduced or the rarefied withdrawn with a greater velocity than that of the carrier, the higher pressure would increase or the lower diminish; if with less velocity, the reverse would take place. It is found, however, in working pneumatic tubes, that the higher and lower pressures both remain practically constant during the whole transmission.

* Paper read before the British Association (Section G) at Liverpool.

Under these circumstances, I found it necessary to attempt to construct a convenient expression for the speeds of carriers of given weight and friction, under various conditions of pressure, gradients, and dimensions of tube, which, although not of necessity strictly theoretically correct, would nevertheless be correct within the errors of observation of its component values, and therefore sufficiently so for all practical purposes.

In dealing with a pneumatic tube, we are fortunately enabled to do this without any elaborate calculation, because we require only to ascertain, under given conditions, the time of transmission of a carrier from one end to the other, or its mean velocity; its actual velocity, at any given point of the length, whether greater or less than the mean, being of no practical importance.

The problem of a successful pneumatic system is simply this: To make a given quantity of air expand from one pressure to another in such a way as to return a fair equivalent of the work expended in compressing it. It is obviously impossible to regain the full equivalent of the work, because the compression is attended with the liberation of heat, which is dissipated and practically lost to us. Therefore, in designing a pneumatic system, that which we have to do is first to contrive means of compressing the air as economically as possible; secondly, to get back as much as we can of the mechanical effect stored up in our already compressed air, irrespectively of the work which was employed in compressing it.

The utmost theoretical work which a given quantity of air can be made to perform, is evidently that of expanding from the higher to lower pressure; and the mechanical effect employed in propelling a carrier and air through a given tube is therefore equivalent of that due to the expansion of a tubeful of air from the higher to the lower pressure.

If the volume of the tube be v, cubic feet, and the mechanical effect performed by a cubic foot of atmospheric air in expanding from the higher pressure to the lower be f (foot pounds), then the work,

F, performed by the whole tubeful of compressed air will be

$$F = v f \text{ foot pounds.}$$

The mechanical effect, f, performed by one cubic foot of air in expanding from p_1 to p_2 (lb. per square inch) pressure is

$$f = 144 \frac{1}{n-1} p_1 \left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} \right] \text{ foot pounds.}$$

in which n=1.408, the relation between the specific heat of dry air when maintained at a constant pressure, and when maintained at a constant volume.

Inserting the numerical value of n, for one cubic foot:

$$(1)\ f = 352.94\, p_1 \left[1 - \left(\frac{p_2}{p_1}\right)^{0.29} \right] \text{ foot pounds,}$$

and for the whole tubeful:

$$(2)\ F = 352.94\, p_1\, v \left[1 - \left(\frac{p_2}{p_1}\right)^{0.29} \right] \text{ foot pounds.}$$

In driving a carrier through the tube, we expend this mechanical effect in accelerating the carrier and the air, and in sustaining them both in motion. The work expended in accelerating the air, we will call A. And if the weight of a cubic foot of air at the higher pressure be w_1 lb., and that of a cubic foot at the lower pressure, w_2 lb., this work of acceleration,

$$(3)\qquad A = \frac{w_1 + w_2}{2} v \frac{s^2}{2g} \quad . \quad \text{foot pounds,}$$

s being the mean velocity of motion, and g the acceleration by gravity, both in feet per second.

The work expended in accelerating the carrier we will call B. This work is expressed by

$$(4)\qquad B = W \frac{s^2}{2g} \quad . \quad . \quad \text{foot pounds,}$$

W being the weight of the carrier in pounds.

After the air and carrier have been accelerated until they assume a mean velocity, s, feet per second, which we will suppose to be constant, the remaining work applied to propel them is, of course, consumed in keeping up this velocity, that is to say, in overcoming their resistance to motion. The mechanical effect, C, absorbed by resistance to motion of air in passing through a tube of the length, l feet, and diameter d feet, is

$$(5)\qquad C = \zeta \frac{l}{d} \cdot \frac{w_1 + w_2}{2} \cdot v \frac{s_2}{2g} \quad \cdot \quad \text{foot pounds.}$$

This item in the expenditure of power is more important than any of the rest, amounting, in general cases, to at least ten times all the others put together.

There exists no definite and satisfactory determination of the value of the empirical constant (ζ), which probably varies slightly, not only with the diameter, the material, and the condition of the surfaces of the tube, but likewise with the density of the air which is passing through. Experiments to determine its value have been made by Girard, D'Aubuisson, Buff, Pecqueur, and others, who give a mean value for it of 0.02.

Lastly, the work (D) consumed in friction of the carrier is

$$(6)\qquad D = Wl\,(\sin \alpha + \mu \cos \alpha) \quad . \quad \text{foot pounds,}$$

in which $\alpha°$ is the angle made by the tube with the horizon, and which is + when the carrier ascends, but — when it descends; μ is the coefficient of friction of motion of the carrier in the tube.

We have, therefore, the value F, foot-pounds of work, balanced by the items of expenditure (A+B+C+D) or

$$(7)\qquad F = A + B + C + D.$$

Setting the algebraical values in this equation

$$(8)\qquad vf = \frac{w_1 + w_2}{2} v \frac{s^2}{2g} + W \frac{s^2}{2g} + \zeta \frac{l}{d}$$

$$\frac{w_1 + w_2}{2} v. \frac{s^2}{g} + W\,l\,(\sin \alpha + \mu \cos \alpha)$$

From which we obtain the mean velocity (s) with which the carrier travels.

$$(9)\ s = \sqrt{2g \frac{v f - W l\,(\sin \alpha + \mu \cos \alpha)}{W + \frac{w_1 + w_2}{2} v \left(1 + \zeta \frac{l}{d}\right)}} \quad \text{feet per second}$$

when going up or down an incline.

But when the tube is level or may be taken as level, α=0,

$$(10)\ s = \sqrt{2g \frac{v f - W l \mu}{W + \frac{w_1 + w_2}{2} v \left(1 + \zeta \frac{l}{d}\right)}} \quad \text{feet per second}$$

If this formula is correct, it should be equally so for small and for large tubes; therefore, we should get equally concordant results in comparing it with experimental data obtained both with parcels tubes and with small letter tubes.

The results of experiments which I am in possession of are very limited in number, but they suffice to prove the general application of the formulæ. The first illustration is the performance of the tube

of the Pneumatic Company, between Euston Station and High Holborn, which was some years ago designed by and carried out under the engineering superintendence of Mr. Rammell and Mr. Latimer Clark. This tube is ⌂ shaped, $4\frac{1}{2}$ ft. broad and 4 ft. high. The tube and its machinery were out of use for some years until it was found desirable recently to employ them in transporting a quantity of materials from Euston Station to Holborn. The trains used were each made up of three trucks, and these were loaded with an average weight of 6 tons, making with the carriages a gross load of 9 tons. The average time occupied in running through the tube from Euston Station to Holborn was $7\frac{1}{2}$ minutes, with a partial vacuum of 5 oz. per square inch, whilst the empty trucks were returned to Euston Station with a compression of 5 oz. per square inch in $6\frac{1}{2}$ minutes. From this we have, therefore, data for two calculations, one way with a load of 9 tons, and the other with a load of 3 tons. We may assume the mean temperature of the air was 20° C, and its mean pressure 14.75 lbs. Therefore, in drawing the loads through to Holborn the air was exhausted to 14.44 lbs., and in sending back the empty carriers it was compressed to 15.06 lbs. per square inch.

With these data, equation 1 gives the mechanical effect, f, due to the expansion of one cubic foot of the air in the two experiments.

Experiment No. 1 (Exhausting).
$f = 31.964$ foot-pounds.
Experiment No. 2 (Compressing).
$f = 31.945$ foot-pounds.

To find the speed of the trains in each case, by formula 10, we have also the data :

For Experiment 1.
$w_1 = 0.07533$ at 20° C.
$w_2 = 0.07302$ at 18.2° C.
$W = 21600$ lbs.

For Experiment 2.
$w_1 = 0.07747$ at 21.1° C.
$w_2 = 0.07524$ at 20° C.
$W = 6720$ lbs.

And the common values,

$l = 9075$ ft.
$d = 4.5$ ft.*
$v = 145{,}200$ cubic ft.

whilst the coefficient of rolling friction of these carriers I found to be 20 lbs. to the ton, therefore,

$$\mu = \frac{20}{2240}$$

These values inserted in formula 10, give the speed as follows:

Experiment 1 (Exhausting).
$s = 20.41$ ft. per second, or 13.91 miles per hour.
Experiment 2 (Compressing).
$s = 23.81$ ft. per second, or 16.24 miles per hour.

And the time occupied in transit from end to end was therefore:

Experiment No. 1, 7 minutes 25 seconds.
Experiment No. 2, 6 minutes 21 seconds.

Whereas we found the time to be 7 minutes 30 seconds in one direction, and about 6 minutes 30 seconds in the other. This result is therefore sufficiently accordant to indicate the correctness of the formula for tubes of this size.

With small tubes the experiments upon velocity are scantily recorded, but I find one of a tube $2\frac{1}{2}$ in. in diameter, laid down some years ago by Messrs. Siemens, at Berlin, between the Exchange and Central Telegraph Station. The report is by Dr. P. Brix, Professor at the Bau-Akademie, and is published in the German "Telegraph Journal."†

He gives the following data, obtained for the purpose of finding the different speeds with equal pressure and vacuum:

"Bei einem zu diesem Zweck augestellten Versuch, bei welchem Ueberdruck . . . . und Unterdruck . . . gleich waren, nämlich 9 zoll Quecksilber, fand sich die Beförderungszeit eines Wagens nach der Börse hin 90 secunden und vonder Börse nach dem Telegraphengebaüde Zurück 70 secunden."

We have, therefore, assuming the tension of the air at the middle point of the line to have been a mean between those of the reservoirs at the pumping station:

Ex. 1 (Compression.	Ex. 2 (Exhaustion.
$p_1 = 19.31$ lbs.	$p_1 = 14.75$ lbs.
$p_2 = 14.75$ lbs.	$p^2 = 10.19$ lbs.

whence by equation (1) supposing the temperature of the outer air to have been 20° centigrade:

Experiment 1 (Compression).
$f = 512.17$ foot-pounds.
$w_1 = 0.1099$ "
$w_2 = 0.0753$ "

* The value of d, which I have given here, represents the equivalent diameter; that is to say, that diameter which, with a tube of circular section, would give the same area as the one under consideration.

† Die pneumatische Depeschenbeförderung Zwischen der Central-Telegraphen station in Berlin und den Börsengebäude daselbst. Zeitschrift des Telegraphen-Vereins-Jahrgang xiii., p. 109.

Experiment 2 (Exhaustion).
$f\ = 529.44$ foot-pounds.
$w_1 = 0.0752$ "
$w_2 = 0.0447$ "

And for each the common values: $W\mu$ —the frictional resistance of the carriers in the tube—averaged 0.1 lb.; the length, b, is 2,920 for each half of the tube ; its diameter, d, is 0.193 ft.; and its volume $(v) = 85.49$ cubic feet.

With these values, formula 10 gives us the calculated speeds in these two experiments:

(Compression).	(Exhaustion).
$s = 34.1$ ft. per second.	$s = 43.2$ ft. per second.

or that the carrier should have occupied in the transit from station to station, whilst compressing, 86 seconds ; whilst exhausting, 68 seconds.

For compression, therefore, our formula gives the time 9 seconds less than that observed by Dr. Brix, a difference due possibly to an error of observation of the pressure, possibly also to the fact that the constant ζ may not be the same for small welded iron tubes as for a large cast-iron tunnel. The difference, however, between the calculated and observed values of the time of transmission by exhaustion is only 2 seconds.

A long length of pneumatic letter line is in contemplation in London in connection with the Post Office telegraphs. When this is at work, I trust to obtain permission to make a series of observations with a view of determining the value of the empirical constant (ζ) for small tubes. The approaching completion of the Pneumatic Company's parcels line with its extension to the General Post Office will enable a series of valuable experiments to be made having a direct bearing upon the future employment of pneumatic propulsion for trains in long tunnels.

In the meantime, I think that the experiments which I have cited were made under sufficiently various conditions, and are sufficiently concordant when compared with the foregoing formula to justify us in assuming, for the moment, that the latter is approximately correct. If so, we are in a position to trace the relations existing between speed, work, performance, and dimensions when the train or carrier is supposed to be so light that we may set the value W=0 in formula 10, which becomes therefore,

$$(11)\quad s = \sqrt{2\,g\,\frac{f}{\frac{w_1+w_2}{2}\left(1+\zeta\,\frac{l}{d}\right)}}\ .\quad \text{feet per second.}$$

And when the tubes are very long in comparison with their diameters, that is to say, when the length exceeds 5,000 times the diameter, we may in practice write the formula thus:

$$(12)\quad s = \sqrt{2\,g\,\frac{f}{\zeta\,\frac{l}{d}\left(\frac{w_1+w_2}{2}\right)}}$$

or by setting,

$$f = \frac{F}{v}$$

in which the volume,

$$v = \frac{l\,d^2\,\pi}{2}$$

in the last quotation, we have the still more simple expression:

$$(13)\quad s = \sqrt{\frac{8\,g}{\zeta\pi}\cdot\frac{F}{l^2\,d\left(\frac{w_1+w_2}{2}\right)}}$$

or inserting the numerical values of the constants,

$$(14)\quad s = 64\sqrt{\frac{F}{\frac{w_1+w_2}{2}}}\ \frac{1}{l\sqrt{d}}$$

It is evident by this equation, that in employing the same amount of mechanical effect, and the air remaining of the same mean specific gravity, the mean speed of transmission varies inversely with the length and inversely also with the square root of the diameter of the tube: Thus with an equal mechanical effect expended upon it in each case, a very light piston would travel through a tube of one mile long with exactly twice the speed with which it would travel through a similar tube two miles long. And further, if we had two tubes each a mile long, one having a diameter of 4 ft., and the other a diameter of 1 ft., the air in the larger tube would only travel half as fast as that in the smaller one, assuming, of course, the total work performed during the transit to be in each case equal. The cause of this is simply that the greater portion of the mechanical effect which in the larger tube is used for moving the greater mass of air, is, in the smaller one, converted into speed. If the case arose, therefore, that a pneumatic transit had to be made with a stated expenditure of work, we

should proceed economically, by adopting a tube of small rather than one of large sectional area.

This is, however, seldom or never the case, as in practice we are limited only to the utilizable power of our blowing machinery. Let this utilizable power be P foot-pounds per second; then,

$$\mathrm{P}=\frac{\mathrm{F}\,s}{l}$$

and

$$\mathrm{F}=\frac{\mathrm{P}\,l}{s}$$

Inserting this value of F in equation 14, the value of s becomes.

$$s=16\left(\frac{\mathrm{P}}{\frac{w_1+w_2.}{1}}\right)^{\frac{1}{3}}\frac{1}{(l\,d)^{\frac{1}{3}}} \tag{15}$$

This equation shows us that with an equal utilized engine power in each case, the mean speeds of transit of air through two tubes, are inversely as the cube roots of their diameters and lengths. For instance, with a utilized effect of 10-horse power, the velocity of transit in a tube eight miles long being 20 ft. per second, that attainable with the same power in a one-mile length of the same tube, would be 40 ft., and if we had two tubes of equal length, one eight times the diameter of the other, the speed attained in the larger tube would be only half that attained in the smaller.

If we had two tubes of different lengths (l and l_1), and of the different diameters (d and d_1) in both, which we wished to attain the same speed, we should have to employ the different utilized powers, P and P_1, and we should have the equation

$$\left(\frac{\mathrm{P}}{l\,d\,\frac{(w_1+w_2)}{2}}\right)^{\frac{1}{3}}=\left(\frac{\mathrm{P}_1}{l_1\,d_1\,\frac{(w_1^1+w_2^1)}{2}}\right)^{\frac{1}{3}}$$

whence, if the mean specific gravities of the air are equal, as in working by equal manometer indications of pressure and vacuum of the two ends of a tube, and the qual

$$\frac{\mathrm{P}}{d}=\frac{\mathrm{P}_1}{d_1}$$

or,

$$\mathrm{P}:\mathrm{P}_1=d:d_1.$$

Therefore, to obtain the same mean speed of transit of a very light piston, in two tubes of equal length, and different diameters, other things being equal, the utilized horse power must be directly proportional to the diameters. In the same way we find that if the diameters are equal ($d=d_1$), but the lengths (l and l_1) are unequal, to obtain equal speed in both,

$$\mathrm{P}:\mathrm{P}_1:l:l_1;$$

that is to say, to produce in the same mean speed of transit of very light pistons in tubes of equal diameter, but different lengths, other things being equal, the utilized horse powers of engines may be taken as directly proportional to the lengths.

Similarly, when the lengths and diameters are equal ($l=l_1$ and $d=d_1$); but the mean specific gravity of air in the two operations are different:

$$\mathrm{P}:\mathrm{P}_1=\frac{w_1+w_2}{2}:\frac{w_1^1+w_2^1}{2}.$$

Therefore, the mean speed of a very light piston being the same, in its transits through the same tube or through two tubes of equal dimensions, the utilized engine power is directly proportionate to the mean specific gravity of the air on the two sides of the piston.

It follows from this, therefore, that in working by exhaustion, less engine power is required, other things being equal, than in working through the same tube by means of compression. And it would also follow that in hot weather, and when the barometer is low, the working of a pneumatic tube should be less costly in engine power than in cold weather, and when the barometer is high.

The influence of the state of the atmosphere upon the working of pneumatic lines (inappreciable of course in small tubes) would become of importance in working such pneumatic lines as that which has been proposed between France and England, supposing for the moment such lines to be possible.

In a tunnel 12 ft. by 13 ft., and 30 miles long, the air would weigh in winter, at the temperature of melting ice, about 750 tons. At the summer temperature it would weigh at the same atmospheric pressure only about 700 tons. Therefore the difference of temperature alone would effect a difference of 50 tons in the weight of air to be moved. Again, supposing the air at ice point to be under a barometer pressure of 31 in. of mercury, whilst at the summer temperature the barometer

fell to 29 in., the weight of air would in the latter case be reduced to about 550 tons, or 200 tons lighter than at the lower temperature and higher pressure. That is to say, the engine working such a line would have 200 tons less weight to move. We see, therefore, that if ever pneumatic engineering works should arrive at a point of development such as the tunnel cited as an imaginary illustration, atmospheric temperature and pressure would be by no means fanciful items in modifying the cost of their maintenance.

Turning back to formula 15, we see that with given utilized horse power operating upon a given line, the velocity of a very light carrier would be reciprocally proportional to the cube root of the mean specific gravity of the air moving in it. Mr. Siemens has proposed to take advantage of this fact by the employment of hydrogen gas for propulsion in letter tubes instead of atmospheric air. The specific gravity of hydrogen is 0.07, that of air being 1. The speed attainable, therefore, by the substitution of this gas would be as

$$1 : \frac{1}{(0{\cdot}07)^{\frac{1}{3}}}, \text{ or as 1 to } 2\tfrac{1}{2} \text{ nearly.}$$

This plan would be easily practicable with Messrs. Siemens's system of complete circuit tubes, in which the same air is pumped round without being changed. With any of the ordinary systems by which the tube is open at one end, of course only atmospheric air could be used in practice.

In conclusion, I think that the foregoing will serve to show that small pneumatic tubes may be worked more profitably than large ones. The great convenience of and practical facilities for working small letter-carrying tubes have been amply proved by the extensive systems already laid down in Paris, Berlin, London, and in other towns, as adjuncts to the telegraph services. Tubes of somewhat larger diameter, such as those proposed some years ago by Mr. E. A. Cowper, for the more speedy distribution of metropolitan letters to the branch post offices, would undoubtedly work satisfactorily. Even still larger tubes, if of moderate lengths, might also be found useful for a variety of special applications; for instance, in the transport of light materials between the different parts of a factory supplied with steam power. But I do not believe that a pneumatic line working through a long tunnel could, for passenger traffic, ever compete in point of economy with locomotive railways. A pneumatic railway is essentially a rope railway. Its rope is elastic, it is true, but it is not light. Every yard run of it, in a tunnel large enough to carry passengers, would weigh more than $\frac{1}{4}$ cwt. And it is a rope, too, which has to be moved against considerable friction; and in being compressed and moved wastes power by its liberation of heat.

In a pneumatic tunnel such as that proposed between England and France, in order to move a goods train of 250 tons through at the rate of 25 miles an hour, it would be necessary to employ simultaneously a pressure of $1\frac{1}{2}$ lbs. per square inch at one end and a vacuum of $1\frac{1}{2}$ lbs. per square inch at the other. The mechanical effect obtained with these combined—pressure and vacuum—would be consumed as follows:

In accelerating the air....	29	millions of foot-pounds.
In accelerating the train..	12	
By friction of the air.....	5721	
By friction of the train...	330	

The resistance of the air, therefore, upon the walls of the tunnel would alone amount to 93 per cent. of the total mechanical effect employable for the transmission; while the really useful work would be only about $5\frac{1}{2}$ per cent. of it. And to compress and exhaust the air to supply the above items of expenditure of mechanical effect, engines would have to exert over 2,000 horse power at each end during the transmission, even on the supposition that the blowing machinery returned an equivalent of mechanical effect such as has never yet been obtained. This would not be an economical way of burning coals. It is desirable, nevertheless, from an engineering point of view, that the merits and demerits of pneumatic parcels lines and pneumatic passenger lines which have been repeatedly suggested during the past half century should be thoroughly investigated. The works of the Pneumatic Company in London, which are approaching completion, will happily settle the question as regards parcels' tubes; whilst the pneumatic passenger railway, which I am told is in rapid course of construction under the streets of New York, will very soon either inaugurate a new era for city railways, or be written in the long list of unsuccessful experiments.

ON THE SEPARATION OF PHOSPHORIC ACID FROM IRON ORES AND IRON CINDERS.*

By JAMES HARGREAVES.

From "The Chemical News."

I need not here enter into any lengthened description of the evil effects of phosphorus upon iron ; suffice it to say that iron containing phosphorus in appreciable quantities is utterly unfitted for the manufacture of steel, and is considerably deteriorated whether it is used in the form of cast or malleable iron. Hence it is desirable to get rid of the phosphorus to prevent its deterioration.

This subject had to some extent attracted my attention for several years, but not so far as to make it a matter of especial study and experiment; but, about five years ago, my attention was more closely drawn to the subject, and I proposed the use of alkaline nitrates as a means of converting cast-iron into steel, and at the same time, separating any phosphorus that might be present. By the use of nitrate of soda I have found it to be quite practicable to produce a good serviceable steel direct from phosphoric pig.

The process, however, was not carried out on a real working scale, for reasons entirely apart from its technical merits, to explain which would be to go into personal matters, which are quite foreign to the objects of this Association. But while engaged in the attempt to develop this steel process, the fact forced itself upon my attention that phosphorus had hitherto been too much looked upon as something to be *got rid of*, and not sufficiently as something to be *got hold of ;* and that to effect the latter would be the best means of effecting the former. It was talked of and regarded by the iron manufacturers as "dirt," but that was because it was "matter in the wrong place," and the only way to make it cease to be dirt was to put it in the right one. I felt this to be a matter of considerable importance, and have often pressed as a subject of study by my fellow chemists, some commercially practical means of obtaining the phosphorus either alone or in some of its available compounds. I pointed this out in a paper read before the Liverpool Polytechnic Society, in November, 1867, and again before the Cleveland Institute of Engineers, at Stockton-on-Tees, in March, 1868. But at the latter place I was simply ridiculed for even alluding to anything so very preposterous, the very fact that there was such an immense amount of phosphoric ores consumed being quoted as a reason why the proposal should be considered impracticable. I refer those who are interested in this subject to the "Engineer" for the earlier part of 1868, for copies of the papers read at Liverpool and Stockton.

It seems, however, that no one has, so far as I can learn, thought proper to give this subject the attention which it deserves —not even those who are most interested in it, and whose opportunities and inducements must be very much greater than my own. In fact, it has almost seemed as if those who would naturally be expected to take the greatest interest in the subject are the last to pay any attention to it. It is one which I was anxious to see carried into practical operation, no matter by whom, as I looked, and still look, upon it as a question of not only pecuniary, but what is immeasurably greater, of vital importance, one affecting health and life, for, in the absence of phosphates, no bony frames can be formed to cover with muscles and endow with vital force ; and one of the limits which bound the existence of man and the lower animals is the quantity of phosphoric acid which can be made available and used as a vital "circulating medium."

I need not dilate upon the importance of a large and practically exhaustless source of phosphoric acid, especially so long as our municipal authorities continue to make use of our streams as convenient conveyances to deposit our supplies of phosphates in the sea, instead of using the sewage to re-fertilize the soil which has been exhausted in the production of food. Seeing this waste (which is nothing less than criminal) one would imagine that we did not expect to be followed by future generations, or else that some one had invented some improvement on the

* Read before the British Association, Liverpool Meeting, Section B.

work of the Omnipotent, and the framework of the bodies of future generations were to be built up without the use of phosphates at all. By proper utilization and conservation of the elements of food, whether in the form of excretal matters or of mineral substances, it is possible that to make "every rood of ground maintain its man" may be not only the aspiration of a poet, but a matter of sober fact.

As an illustration of the quantity of phosphorus which is present in the iron made in Great Britain, I may point to Cleveland, which manufactures $1\frac{1}{2}$ millions of tons of iron per annum. This iron, at the low estimate of $1\frac{1}{4}$ per cent., contains 18.750 tons of phosphorus, which is equal to 42.943 tons of phosphoric acid. This phosphoric acid is sufficient to supply the phosphoric constituents to 3,400,000 tons of wheat. In the absence of strict statistics on the subject, it is not too much to assume that, in the whole of the British iron manufacture, this quantity might be tripled, with every confidence that it is considerably under rather than over the fact.

When phosphoric pig-iron is converted into malleable iron, the phosphorus is, in great part, transferred to the refinery and puddling furnace cinder in the form of phosphate of iron. The quantity of phosphoric acid varies of course with the composition of the pig-iron from which it is contained. The cinder produced from refining and puddling Cleveland pig contains generally from 3 to 7 per cent. of phosphoric acid, which is from one-fourth to one-half the phosphoric acid present in good commercial soluble phosphate of lime. This cinder is sometimes again used for the manufacture of pig-iron, but the product is, on account of the accumulation of phosphorus, of small commercial value, while, if the phosphoric acid were previously separated, it would be capable of yielding iron quite equal to that produced from hematite, or could be again used for "fettling" puddling furnaces.

While at this part of the subject I may refer to the contradictory and incoherent theories given to account for the separation of phosphorus from the iron and its transference to the cinder while being converted into malleable iron by the ordinary refining and puddling processes, while in the Bessemer process the amount of phosphorus separated is very small. I could get no satisfactory explanation from other sources, and, therefore, made these reactions a subject of study and experiment for over three years, and I gave the results in a paper read before the Liverpool Polytechnic Society. To repeat this would extend this paper to too great length, and I must refer those who take an interest in the subject to the "Journal" of the Society for May, 1869.

The concentration of the phosphorus from the pig into the cinder in the form of phosphate of iron renders it more easy and practicable to separate when the preparation of compounds of phosphoric acid is the object in view, as there is a smaller bulk of material to be treated to obtain a given amount of product.

The phosphoric acid may be separated either in the form of soluble superphosphates of lime and magnesia or of the alkaline tribasic phosphates. To effect the former the cinder is melted with lime and magnesia ; and to do this it is best to either use lime in the furnace during puddling, or else add it at the end of the operation before the cinder is run out, so as to save the fuel required to re-melt it. This is then roasted in the ordinary way of making what is technically called "bulldog." By this roasting the protoxide of iron is converted into magnetic oxide or into peroxide of iron, both of which are very slowly soluble in cold dilute hydrochloric acid, while the phosphate of lime is readily dissolved out, leaving the oxide of iron and silica behind. Or, instead of fusing the cinder with lime, it is first dissolved in hydrochloric acid, the silica being left behind insoluble, except a small proportion of gelatinous silica ; sufficient lime or chloride of calcium is added to saturate the whole of the phosphoric acid present in the cinder. The chloride of iron is then concentrated to dryness. If in an open reverberatory furnace and in an atmosphere containing water vapor, hydrochloric acid is again liberated, which can be condensed and used again to dissolve more cinder. The peroxide of iron is then heated to redness to render it insoluble, and cold dilute hydrochloric acid added, which dissolves out the phosphate of lime, leaving the oxide of iron nearly pure. If it is desirable to obtain the chlorine in its isolated state instead of in the form of hydrochloric acid, the chloride

of iron is dried in a close vessel, and dry atmospheric air passed through it at a temperature about the melting-point of zinc ; the chlorine is liberated and peroxide of iron formed. The manufacture of chloride of lime or bleaching-powder can, therefore, be economically carried on in connection with the manufacture of phosphates and pure iron oxide, dispensing with the use of manganese, and with the further advantage that a given amount of hydrochloric acid will produce double the amount of chlorine that can be produced by the use of manganese. To obtain phosphate of soda, I keep the cinder free from lime and grind it to a powder, then I add a solution of caustic soda in good excess, so as to separate the whole of the phosphoric acid from the cinder before throwing the cinder out, and add the solution of phosphate and excess of caustic soda from that to an excess of cinder, so as to convert the whole of the caustic soda into phosphate. The partially exhausted cinder is then again treated with an excess of caustic soda to separate the whole of the phosphoric acid. The diphosphated cinder still contains the silica originally present, and it seems to combine with some of the soda used to dissolve out the phosphoric acid, as there is often 20 per cent. of the soda used remaining in the cinder. This cinder may be again used to fettle puddling furnaces, and the soda present in it cannot but facilitate the transformation of the phosphorus in the pig into phosphoric acid in the cinder; the presence of the silica, however, is objectionable, on account of its neutralizing a great proportion of the bases present in the cinder. It is desirable that the cinder produced from the fettling and the iron together should be as free as possible from anything which can saturate the basic material, so as to allow of a greater amount of free base, which readily facilitates the formation of phosphate of iron. To allow of this when making phosphate of soda, I dissolve the cinder the same as before mentioned, leaving the insoluble silica behind. The chloride of iron is then dried and used in the production of chlorine, or the hydrochloric acid may be again recovered to use over again. The oxide of iron, *plus* phosphate of iron obtained after the separation of the chlorine, is then treated with caustic soda to obtain solution of phosphate of soda, the practically pure oxide of iron remaining insoluble. The phosphoric acid in the iron ores exists principally as phosphate of lime, which, in fact, is the remains of extinct animals. To separate the phosphate, the ore is roasted so as to render the oxide of iron insoluble. The ore is broken into suitable sized pieces, say about 2 in. cube, and cold dilute hydrochloric acid run through it, which takes up the phosphate into solution, leaving the oxide behind.

The limit to the manufacture of the acid phosphate is, practically, the quantity of hydrochloric acid which is produced in the manufacture of sulphate of soda, over and above what is required for the manufacture of bleaching-powder and a few other purposes. The exact quantity of this acid I have not had time to ascertain with any degree of accuracy, but in the alkali works on the Mersey, and it is much the same in other places, there are literally brooks of hydrochloric acid run to waste; besides, the fact that the acid at present used in the manufacture of bleaching-powder can, by the use of chloride of iron process, be reduced to $\frac{1}{2}$, and, in many cases, to less than $\frac{1}{3}$, its present quantity, will liberate a still further supply of acid to be used in the preparation of acid phosphates. There is here an opening for the consumption of a great amount of valuable material which is at present run to waste. There is, of course, no practical limit to the further production of hydrochloric acid, whatever may be the quantity required, if a rise in price should occur sufficient to justify its special manufacture, and the manufacture of phosphate of soda is also unrestricted so far as supplies of soda are concerned.

The only objection to the use of such hydrochloric acid as is produced in the course of the alkali manufacture, is the presence of arsenic. This, however, is practically a small difficulty, the same person who produces the hydrochloric acid also produces sulphide of calcium in the shape of alkali waste. A current of sulphide of hydrogen (which can easily be produced from the waste) passed through the acid readily precipitates the arsenic in the form of orpiment, for which there is a regular demand at remunerative prices. The separation of the arsenic will, if fairly attempted, more than pay for the cost of obtaining it.

ROLLING LOADS.

From "Engineering."

In the present day, excepting only Government wagons, rude agricultural carts, and wheelbarrows, everything running upon wheels is seated upon springs. This fact is a practical acknowledgment of the essential difference between a moving and a stationary load. When a vehicle is at rest the deflections of the springs are constant, and afford as exact a measurement of the insistent load as could be obtained by taking the wheels over a weigh bridge. If the load continued to press with the same intensity upon the wheels when in motion springs would be useless, as their deflection would remain unaltered, and a solid block might, consequently, do their work. But experience has taught us that on the smoothest railroad the springs are at once sensitive to the slightest movement, and that they may be advantageously introduced, and come freely into play, even in the instance of the slowly-revolving turned rollers travelling on the accurately-faced roller-path of a large swing bridge. The deflection of the springs of a vehicle in motion is alternately greater and less than the mean deflection when at rest, and the irresistible inference is that the wheel will press upon the supporting medium with a maximum intensity corresponding to the greatest deflection of the spring. No better opportunity of appreciating the practical effect of this condition could be obtained than is afforded by the running of a couple of trains at high speed in parallel lines and in the same direction. The observer in one train can then note the movement of the springs, with the horizontal element eliminated and the vertical alone apparent. It is hardly possible under these circumstances to avoid drawing a parallel between the train and a ship in a moderately smooth sea. The rising and falling of the several springs correspond with that of the waves, the mean deflection and the mean line of flotation is the same, respectively, as when the train is at rest and the ship in perfectly smooth water; but the maximum stresses must be deduced from the maximum deflection of the springs in the one case, and from the immersion measured from the crest of the waves in the other; a very long railway carriage with a large number of wheels would have no vertical movement itself, neither would a very long ship. Expanding this deduction, we are led to the conclusion that a long-span bridge will suffer no increase of strain from the varying deflections of the springs induced by the unavoidable deviations from mathematical accuracy in the levels of the permanent way, although the rails themselves may be subject to strains some 30 per cent. greater than those due to the load at rest.

There may, however, be some other agency at work increasing the strains under a rolling load beyond that evidenced to the senses by the springs; and, as this is a question of paramount importance in the economic design of railway bridges, it is no matter for surprise that it has engaged the attention of the most eminent mathematicians and experimentalists. The results of the earlier experiments on the influence of rolling loads were certainly very alarming, as they appeared to indicate that one ton moving at 30 miles an hour was as destructive to a beam as $2\frac{1}{2}$ tons at rest. Observations of the deflections of actual bridges, however, soon reassured engineers, as the deflections under speeds of even 40 or 50 miles per hour were not practically greater than those due to the same load at rest. Theoretical considerations, at first sight, might erroneously lead us to anticipate a greatly increased deflection under a rolling load, since they indicate the maximum deflection of an elastic beam under a suddenly imposed load to be double that of the final deflection after oscillations have ceased. The reason for this is obvious enough, for the work done by the beam must be equal to that done by the load, and as the latter is equal to the product of the load into the ultimate deflection, the former must be equal to the product of the mean resistance of the beam into the same deflection; hence the *mean* resistance of the beam must be equal to the load, and as the resistance is *nil* at the commencement of the bending, it must be equal to double the load at the termination.

But the conditions of the rolling load

on a railway bridge are not analogous. The load is not sufficiently suddenly applied, and the horizontal motion and *vis viva* of the train destroys other conditions. It might at first be concluded that at least the cross girders of a bridge spaced at intervals of a yard only, and where consequently at 60 miles per hour the load would be imposed in the thirtieth part of a second, would constitute a case of suddenly imposed load and double strain, but experience does not bear out this conclusion. In an instance observed by the writer the deflection of some 8 in. cross girders, amounting to $\frac{3}{8}$ths of an in. under the driving wheels of the engine when at rest, was increased to $\frac{1}{2}$ in. only when the engine traversed the bridge at considerable speed. In fact, in this case it was evident that the work done in deflecting the several girders was not performed, as in the case of a suddenly applied load, by a *vertical* descent of the weight at each girder, but by increased *horizontal* traction on the whole train ; in the same manner as the wheel of a road vehicle passing over soft ground consolidates its path by the formation of a rut, at the expense of an additional pull, and not by an up-and-down hammering of the wheel.

One element of increased strain on the main girders of a railway bridge under a moving load is sufficiently apparent, but on investigation turns out to be insignificant in effect. The rails, if normally horizontal, will obviously be deflected below the horizontal line when the load is traversing the bridge, and the path of wheels therefore will be approximately an arc of a circle. The resulting centrifugal force will take effect upon the girder in a practically vertical direction, and in terms of the load the increased bending stress will, of course, be equal to the square of the velocity in feet per second, divided by 32 times the radius of the deflective curve in feet. In practical cases this increase, as we have before observed, will be found insignificant.

The most recent researches of mathematicians show that the passage of a train of ordinary length does not afford sufficient time for the attainment of molecular equilibrium in the girder, and that the increase of strain is not worthy of note. M. Bresse has shown that with a train of indefinite length, moving at the highest practical velocity, the strain, neglecting the effects of possible concussion, may be one-third greater than that due to the same load at rest ; but that if the initial camber of the rails be four-thirds of the statical deflection, this increase, under the same reservation, will not take effect.

It is apparent, therefore, that if any important modifications are required in girders subject to a rolling load, it can only be to provide against the effects of shocks arising from irregularities in the roads and other similar causes. The interposition of springs protects the ironwork from direct impact, or some difficulties would be encountered in dealing with the light cross girders of railway bridges. Experiments on the effect of falling weights give very conflicting, and in some instances, unintelligible results. We can easily understand that a rectangular bar of any proportions, provided it be of the given weight per foot, will stand the same intensity of blow, whether it take effect on the flat side or on the edge of the bar ; because the work done in fracturing the bar will be proportional to the product of the breaking weight into the ultimate deflection, which will be a constant amount for all rectangular bars of a given span and weight per foot. It is not so apparent, however, that a round bar of the same weight per foot will sustain the same blow as the rectangular bar, nor that the deflection will be proportional to the velocity of impact instead of the square of the same, yet both these are deduced facts from experiment.

The general tenor of the evidence gradually accumulated by engineers relative to the effect of moving loads tends to prove that no additional strength is on that account required in the main girders of railway bridges above some 20 ft. in span, provided the permanent way be kept in fair order, but that the cross girders should be calculated to sustain the load corresponding to the maximum deflection of the springs, which will ordinarily be some 25 per cent. greater than the normal load. There are no grounds for the adoption of a factor of safety of ten in railway practice where moving loads are concerned, as urged by some writers, although that factor is quite justifiable in the instance of machinery, where genuine sudden strains have to be encountered.

ON LIQUID OR CONCENTRATED FUEL.*

By Captain J. H. Selwyn, R. N.

From "Engineering."

In continuing the subject of liquid fuel before the Institution of Naval Architects this year, I wish to draw attention specially, to the value of the principle of concentration, which is involved in the use of such a combustible.

I have, therefore, headed the paper with a double title, of which one part refers to the liquid condition of the fuel, the other to the fact of its being highly concentrated. In order to understand what is the importance of this lat er fact, we have only to consider how seriously we should be inconvenienced in our use of fuel if nature had not supplied us with large stores of what was no doubt originally vegetable substance, but is now condensed into the form of coal. So long as forests of great size admit of our resorting to them for our supplies of fuel, they are sufficient for the wants of mankind, at least in their immediate neighborhood; but their use becomes too expensive so soon as distant transport is an element of the question. As for steam navigation, no fuel in a less condensed state than that of coal could possibly be used largely for long voyages.

But we have certainly not yet come to the end of what may be useful concentration of our heat-producing agents, and I am about to draw your attention anew to the way in which this may be done and the advantages of doing it.

Since I last addressed the Institution on this subject I have continued the experiments on which I was then engaged at Woolwich up to the time at which the closing of that yard put a stop to them; I hope to see them resumed, and carried to a legitimate conclusion, but I cannot go to much expense myself, and so little is now allowed to be expended even on the most useful experiments by the Government, that it is extremely doubtful when the authorities will consent to do what would inevitably save many thousands of pounds to the nation, were it done. In order to convince you that I am not overstating the economy to be expected and the convenience that may result from the further experiments which I advocate, I will now, after a short recapitulation, place before you the facts on which I ground such an opinion.

I showed in my last paper that the chemical analysis of the oil used entitled us to expect that its theoretical calorific value, that is the number of pounds of water 1 lb. of the oil I used might theoretically be expected to evaporate, would be 17.5. I also showed that in a trial at Woolwich in the Oberon boiler, in which economy was the sole object and quantity was ignored for the time, 16.9 lbs. of water were evaporated, and although the quantity in a boiler of 1,702 sq. ft. of heating surface was then only about 60 cubic ft. per hour, I assured you that this was only because no more oil could be burned in that trial on account of an insufficient supply of steam from the small boiler which served the injectors. The trials were continued with such alterations as were found to be most productive of good results from April to July, 1869, and at the latter date we had succeeded by a gradual amelioration, and by taking the steam for jets from the large boiler itself, in increasing the quantity to 236 cubic feet per hour, with an economy of 14.9 *both after* deduction of the water or steam used in the jets. But at this point of my observations I must entirely refuse to concur in the propriety of any such deduction being made, and this for two reasons. First, because from the experiments of Bunsen and Fyfe, names which command the highest confidence among chemists of all nations, it appears, that red hot coal and "aqueous vapor mutually decompose each other into hydrogen and carbonic oxide gases with some carbonic acid, both of which, if sufficient oxygen be present, burn with the production of a white heat, to form water and carbonic acid, and that numerous observations showed further that the additional heat evolved *more than compensated* for the fuel used in producing the vapor." Secondly, because, as you will see from the tabulated form, which is official (except where special figures are shown) at a time when 16.1 lbs. of water were being evaporated by the use of each

* Paper read before the Institute of Naval Architects.

pound of oil (the theoretic calorific value being 17 5) the temperature of the chimney or that of the escaping gases was 680 deg. Fahr. Now according to one of Professor Macquorn Rankine's formulæ, which runs thus :

$$\text{Loss up chimney} = \frac{1+A \times T \cdot C}{4000 \text{ Fahr.}}$$

1+A is here 16.3 the weight of burnt gas, and T.C is temperature of chimney. Then 680 deg. Fahr. corresponds to a loss of 2.7 units of heat or pounds of water vaporizable. Now deducting the evaporation actually obtained, namely, 16.1 from 17.5, the theoretic ultimate calorific effect of the oil, we have 1.4 which might possibly be due to the oil. But how shall we account for the other 1.3 of heat in the escaping gases, unless we allow that this is a corroboration of Bunsen and Fyfe's observations, and that consequently the water used in jets ought not to be deducted from the total evaporation of water from the constant of 212 deg. feed.

At any rate I think it fair to show you what would be the results if this be the right view, and you see the special figures showing 254 cubic ft. evaporated per hr. at the rate of 16.1s lb. for every pound of fuel consumed. 'As this is done with a boiler whose total heating surface is 1702 sq. ft., it amounts to a cubic ft. of water evaporated per 6.7 sq. ft. of heating surface with an ordinary tubular marine boiler situated on a cold wharf, and only partially lagged or covered with felt. This duty was performed by the boiler with the ordinary arrangements of firebars, ashpit, and firedoors, and there was nothing to prevent coal from being burned the next hr., or at the same time if desired. The experiments with the firebrick combustion chambers, built in the ashpit, did not turn out to be superior in results to those arranged as above, and as such an arrangement necessitates the use of a small auxiliary boiler to raise steam in any moderate time, they were discontinued. This, however, might not be the case with a different type of boiler. I am of opinion that the results above described might yet be beaten in the same boiler if a higher class of oil and more steam were used ; but as it was, I was obliged to be careful, since even with a large steam pipe open, besides the jets, the safety valves were not always able to prevent the pressure rising beyond the 24 lbs. at which we were working. It was, of course, necessary then to shut off some of the oil, which is done by a mere touch It will be remembered that, while with coal no more than a certain number of pounds can be placed on the grate so as to burn, there is no other limit to the quantity of oil that may be burnt than the supply of steam to the injectors, or in a short boiler the loss of heat up the funnel.

As regards safety, there is no longer the slightest doubt on the minds of those who use this fuel. The oil only differs from ordinary train oil in this particular, for the reason that train oil would float on, but this oil sinks under, salt water ; it is therefore less liable to accidental combustion, and more easily put out, should it ever inflame when substances are thrown into it that may act as wicks. A white hot firebrick may be plunged into the oil with the most perfect impunity. If shavings are thrown in and set on fire, these form wicks, and the oil burns as train oil would do, but water will instantly extinguish even this. In short, I confidently state that all idea of danger may be dismissed at once and for ever with an oil whose specific gravity is 1050 and upwards.

I can only account for its not having already come into general use as fuel by three considerations. First, the prejudices which invariably retard new applications of knowledge. Secondly, the attempts of holders to realize high prices before the economies derivable have become fully known ; and thirdly, because several persons have thought they could do without those who had studied the question, and have, therefore, only succeeded in burning the oil wastefully.

I am satisfied that there is an ample supply of material from which the oil can be obtained at a remunerative price, that shipowners can well afford to give from £2 to £3 a ton for it when they know its use thoroughly, and that it is at this moment cheap to use it at the 30s. per ton of 213 gallons which is asked for it, seeing that if 1 ton of it used without stoking, be it remembered, is equal to 2 tons of coal in evaporative duty, if that ton only takes 36 cubic ft. of space instead of 92, which 2 tons of coal would occupy; if again every drop of the oil does its work, while there is a large proportion of ashes and slag in the coal ; if, I say, these and other economies, not so apparent, but still im

No. of Trial.	Date of Trial.	Time.						Coal Consumed in Raising Steam Small in Boilers.	Fuel Consumed in Raising Steam in Trial Boilers.
		Lighting up in the Small Boiler.	Steam up to 20 lb. Pressure.	Occupied.	Lighting up in the Trial Boiler.	Steam up to 15 lb. Pressure.	Occupied.		
19	July 1, 1869	a. m. 8.0	a. m. 9.05	h. m. 1.05	a. m. 9.25	a. m. 10 15	h. m. 0.50	lb. 160	lb. 610 coal. 120 oil. 730 total.

Time.			Temperature.				Weights.		
Commencing the Experiment.	Ending the Experiment.	Occupied on the Experiment.	Water in the Boiler on Lighting the Fires.	Feed Water.	Atmosphere.	Bottom of Funnel.	Mean Pressure of Steam.	Oil Consumed during the Experiment.	Water Evaporated during the Experiment.
p. m. 12.40	p. m. 5.02	h. m. 4.22	Fah. 141°	Fah. 62°	Fah. 70°	Lead melts	lb. 24	lb. 4312	lb 59036

Oberon Boiler, Tubular Marine Heating Surface in Tubes 1468 Square Feet in Furnace, and Uptake, 234 Square Feet; Total, 1702 Square Feet.

Water Evaporated to 1 lb. of Oil Consumed.						Heating Surface per Cubic Foot of Water Evaporated per Hour at Constant Temperature of 100° Fahr.	Oil Consumed per Hour.
At the Actual Temperature of the Feed Water.	At the Constant Temperature of 100° Feed Water.	At the Actual Temperature of Feed Water after Deducting the Water Used for the Jets.	At the Constant Temperature of 100° Feed Water after Deducting the Water Used for the Jets.	After Deducting Water Used for Jets at the Constant Temperature of 212° Fahr.	Without Deducting Water Used in Jets from Constant Temperature of Feed 212° Fahr.		
lb. 13.70	lb. 14 11	lb. 12.70	lb. 13.11	lb. 14.98	lb. 16.16	sq. ft. 7.65	lb. 989.00

Water Evaporated per Hour.						Approximate Amount of Water Evaporated for the Use of the Steam Jets.			
At the Actual Temperature of Feed after Deducting Water Used for Jets.	At the Actual Temperature of Feed without Deduction.	From the Constant Feed of 100° Fahr. without Deduction.	From the Constant Feed of 10 ° Fahr. after Deduction of Water Used for Jets.	From the Constant Feed of 212° Fahr. without Deduction.	From the Constant Feed of 212° Fahr. after Deduction of Water Used for Jets.	During the Experiment.		Per Hour.	
cub. ft. 200.08	cub. ft. 215.90	cub. ft. 222.39	cub. ft. 208.08	cub. ft. 254.76	cub. ft. 236.09	lb. 4312	cub. ft. 69.00	lb. 989.00	cub. ft. 15.82

portant, are to be considered as they deserve, then no long time ought to elapse before it is brought into use in our commercial marine.

But of course I am more especially anxious that our navy should profit by it, and what I now desire is, that having proved so much in a steam launch first, and then in an ordinary marine boiler on the wharf, the next step should be taken of fitting it in a gun vessel of moderate size, whose performance is already, known well in order to test it fairly at sea, and to estimate accurately what may be the subsidiary economies that attends its use there, in order to know what price can be given for larger quantities when required. Then the condensation of which I spoke will take place as an ordinary fulfilment of the law of supply and demand, the light spirits, and other products including illuminating oils, will find their proper market, and the distiller of such will no longer consider so large a proportion of his distilled products as mere waste unsalable at any price. This was, I am informed, the case at Wareham, near Poole, where the distillation of shale (forming cliffs along that coast) was once carried on with a result of 50 gallons of crude oil to the ton of shale, or Kimmeridge clay.

This distillation was voted a nuisance by the inhabitants, as it was attended by a very disagreeable smell, which was, however, solely due to the fact that the distillers did not then provide means of burning these gases under the stills, as they might, and ought to, have done with considerably increased economy in the production. I believe the process established at Chatham by Messrs. Dorsett and Blythe for heating armor plates, etc., by liquid fuel, is still carried on there with admirable results. Mr. Barnes, of Victoria-park, also continues to speak highly of the apparatus of Messrs. Wise, Field, and Aydon fitted to his steam boiler, and I know that some mercantile men are anxious to fit it in their steamships as soon as practicable.

It is essential to the proper burning of this oil that it should not, while entering into combustion, be cooled down in any way, and a mass of fire-brick, slag, or other rough material on the fire-bars, forms a very good heat governor, but the ashpits and firedoors ordinarily fitted are decidedly not the best that we could have. Some flame (as a piece of lighted wood or cotton waste) should always be in the furnace when turning the oil on. The existing form of injector can scarcely be improved on, excepting in very large furnaces, where they ought to be double. In some cases the oil may be sucked up from tanks placed below the boilers, by the steam that burns it. The higher the pressure and the drier the steam the better. Superheated steam is always preferable ; for the jets and this should be made in the chimney where the heat passing off is otherwise clear waste. Joints for the oil should be made with lime and glue ; no red lead joint is of any use. As little water as possible should be allowed to mix with the oil, otherwise the fires are soon put out, though the water will always keep at the top of the oil unless much agitated.

The raising of steam in all these last experiments was done as in an ordinary coal boiler, and the steam, when raised, was taken to the injectors from the large boiler itself. No sweeping of tubes or clearing of fires was ever necessary from November, 1868, to July, 1869.

I have now only to draw your attention to the tabulated results, and to request you to recollect my statement of last year, that the mean obtained with the boiler on trial in a stoke hole whose temperature was 95 deg. Fahr., with best steam navigation coal, were 8.2 lbs. of water evaporated per 1 lb. of fuel and 200 cubic feet of water per hour, both calculated from the constant of 100 ft..which I do not approve, as it takes no account of the latent heat, and does not give any real estimate of calorific power comparable with the chemical analysis of the fuel experimented with. I have now fulfilled the promise of further information made by me at your last session ; and while I feel grateful to the Admiralty for enabling me to carry on the experiments so far, and to those who have contributed in various ways to take a portion of the burden of them from my shoulders, I feel also that it is my duty not to relax my efforts to get the investigation continued, and still more light thrown on the question, and in the hope that I shall succeed in these efforts, I renew my promise, if all be well, of another communication in continuation of the same subject for the session of 1871.

SEA WALLS AND FORESHORES.

From "The Engineer."

The heavy gales which at times rage about our coasts occasion very great damage to the sea walls and paved foreshores of the kingdom. Immense is the first cost of these gigantic works, extending continuously in many places for 10 or 15 miles, and tens of thousands of pounds are spent annually in repairing them; the reason of the continued destruction of such works being that the sea obtains access under or through the interstices of the sea walls or long sloping foreshores, and either undermines, or, by hydrostatic action, forces the stones out of place. Vast destruction of property at times ensues, and, indeed, whole districts are occasionally laid under water by such inroads of the sea. The difficulty encountered in forming foreshores of a permanent character consists in the absence of a cement which should have the property of hardening rapidly in water, combined with durability. It is found that the interval of a tide is not enough to enable the best cements in use to harden before the returning tide or sea, which, when strong, displaces the cement partially or wholly; but when, through fortunate circumstances, it is enabled to set, the sand and gravel dashed against the wall in heavy gales tears and abrades it away in a year or two, and the danger and expense are again incurred. Some years since, Captain Cochrane, R. N., of the Junior United Service Club, induced Mr. Elliott, the engineer superintending Dymchurch wall, to try a cement made from bitumen found in one of his estates in Trinidad, one ton of which, mixed with about nine tons of gravel and a little gas tar and lime, forms an extremely cheap material admirably adapted for the purpose of cementing sea walls. Captain A. Cochrane has favored us with the following copies of Mr. Elliott's report, which will be found extremely interesting to engineers. Experiments go to show that the tenacity with which bituminous cement adheres to stones, iron, bricks, or wood, and the rapidity with which it sets is so great, that when once joined, and the material broken with a hammer, the fracture is generally through the bricks or stone, in preference to the adhering film of cement.

Mr. Elliott, writing from Dymchurch, 24th March, 1860, to Captain Cochrane, says:—

"Sir,—The time has now arrived when a decided opinion may be given on the merits of the 'bitumen' you sent me for experiment on the sea wall at Dymchurch. It may, perhaps, be well for me to state that the slope of the sea wall lies on an inclination of about seven to one, faced with Kentish ragstones in large irregular blocks, very roughly dressed, having considerable interstices to be filled with the sand and shingle constantly passing over it. With an off-shore wind from N. E. to W. there is no difficulty in keeping these interstices full, and when this is so, but little damage ever occurs, although a heavy sea from ground swell may be falling on the face of the wall. With an on-shore wind from S. W. by S. to N. E. by E. the very reverse of this takes place, the whole of the sand and shingle is washed out of the joints, the paving becomes loose, and frequently breaks up to a large extent. Seeing all this occurring from year to year, I have, for many years, been anxiously looking out for some material that would stand the wear and tear of the sea (mixed up, as it is, in every gale with a mass of sand and shingle), easy of application, so as to prevent the sand and shingle being washed out of the lower portion of the joints of the paving. No cement that I have yet tried—and I have tried various —will stand the heavy surf and scouring for more than a week or two. Owing to the lateness of the season, 1858, when I received the bitumen from you, I was unable satisfactorily to cover but a very small space of the stone paving from the difficulty in getting the stonework sufficiently dry during the ebb of the tide. However, I was very anxious to see the results of this (to me) new material; so, with a little perseverance, I got about 500 sq. yds. of the stonework pointed up; that is, I had the joints of the stonework picked out as deep as we could, and then filled with the bitumen, mixed in the proportions you advised it to be used. The result of this small experiment was, to my mind, very satisfactory. I found it soon set firm, and adhered well to the stones,

a point which I had some fears about when using it, as we could not at that season of the year [November and December] get the stones to dry as I could have wished, and as we could have easily done in the summer time. This portion after sixteen months' trial, remains, to all appearance, as it was on the day it was put down, only a very few portions having been washed off, and these very evidently where water had collected in the hollows of the stonework. and proper care had not been taken to dislodge it before filling up with bitumen. The incessant scouring of the sand and shingle for sixteen months seems to have had but little effect on it, while the very best cements, both Roman and Portland—in various states of combination with shingle, gravel, and pouzzolana—have invariably been scoured off and utterly gone in a few weeks. In the spring of 1859 I used up all the bitumen I had remaining, which enabled me to point up in the same way as that done in the previous autumn about 1500 sq. yds., in addition to the 500 then down. In this I have taken some liberties with the proportions of bitumen, lime, gravel, and tar that you furnished me with; it appeared very evident to me that the bitumen, without any loss to its properties of cementing, would take a much larger proportion of clean shingle and gravel. I increased this proportion until I had doubled the quantity of gravel, that is twelve to one instead of six to one, I also omitted the oil of tar, using in lieu of it a double quantity of gas tar. I am of opinion that for the purposes we required in filling in the large interstices of the tone-work, the proportion of clean shingle or gravel could be still further increased, thus very materially diminishing the cost, a very material question in the immense surface we should have to cover. In addition to the 2,000 yds. 'pointed up' I selected a space of about 200 yds. of the very worst portion of the wall, that is where the stone paving was most worn and open, my object being to bring this rough and open surface to as smooth and even a face as possible; to do this in many laces the bitumen would be 6 in. or 7 in. n depth, in these large places. While he bitumen was in a plastic state I forced into the mass as much as I could of broken pieces of stone, Kentish rag, somewhat larger than would be used for road repairs; these at once set firmly, and altogether made the most satisfactory work. The whole of this 2,200 yds. was selected on the slope of the wall between high-water spring tides and high-water neap tides—so that every tide washed over it more or less. I selected this position because it is there where we invariably get most damage, and it is there in particular where we require better protection than we have hitherto been able to get. What I have done has now passed through, first, one of the hottest summers we have had for many years; and, secondly, it has also passed through by far the most severe winter, for storms, cold, and wet, that I have ever experienced, and I have had constant charge of this sea wall for more than twenty years. Five months, and not one week without a gale of wind; nearly 40,000 yds. of the stone paving on the wall has been broken up, but not one yard where the bitumen had been employed. It has been broken up above and below it, and on either side, thus giving, in my opinion, the most conclusive proof of what inestimable value this material would be in so extensive and important a work. Neither cold nor heat affects it in the least, as far as durability is concerned; a very hot sun softens the bitumen to some little extent, but this in my opinion is an advantage rather than otherwise, as this softening tends effectually to fill in any vacant space that may exist in the stone-work, and thus thoroughly adapts itself to the irregularities of the stone-work, the surface being rendered hard the moment the flowing sea reaches it, and then no amount of friction seems to have any effect on it. I found the cost of applying the bitumen, as I have stated above, to be as follows:—The 500 yds. done in November and December, 1858, cost 7½d. per yard; the 1,500 yds. done in the spring of 1859, 4½d. per yard; and the 200 yds. 18d. per yard. This is calculating the bitumen at £4 10s. the ton. I consider the last portion of 200 yds., at a cost of 18d. per yard, to be in every way the most satisfactory. I cannot conclude this report without thanking you most cordially for your great liberality and kindness in placing me in a position to carry out these experiments almost free of cost. Important as the question may be, it is well known that it is no easy matter to induce non-scientific men to incur expense in experiments—with what to them may be a novelty—and

the results of which may be doubtful. Thanks to your liberality, I have avoided this difficulty, and with the self-evident fact before us, I hope at no distant day to induce the authorities having charge of this subject to carry these experiments to a much greater extent."

Mr. Elliott wrote again to Captain Cochrane from Dymchurch as follows :—

"DEAR SIR,—In the spring of 1860 I sent you a report on the results of the trial of a few tons of bitumen I had used on the sea wall at this place during the two previous years. At the end of ten years it will, I have no doubt, be interesting to you to learn what I can now report on the matter. By referring to my previous report you will find that I pointed up about 2,000 sq. yds. of the stone paving, forming the long seaward slope of the sea wall, that is, all the sand and shingle in the joints of the stone paving was picked out some 2 in. or 3 in. deep, and then filled in full with hot bitumen, so as to make a tolerably even surface to the work. This stood the wear and tear of the sea for about eight years, and showed but little or no change ; but in the winter of 1866-7 the whole mass was torn up, rocks, bitumen, and earth below going in one general wreck. If we had taken the precaution of securing the ends of the paving over which the bitumen had been used, this part would, I have no doubt, weathered the storm, as the breach in the paving began at some distance from where we had used the bitumen. Once there was an opening below it, there was soon a clean sweep of the whole rock paving in the neighborhood, the sea paying but small respect to the paving, or bitumen, or anything else in its way. You will find in my report (1860) that I had selected a space of about 200 yards, where I had used the bitumen in larger masses, that is, where the joints and angles of the rock paving were worn away to a very considerable extent. Of this 200 yards the weather we had in 1866-7 carried away about one-third in the same way as the other, from a general breach, the sea getting under paving and carrying it away in masses ; but about two-thirds of this 200 yards still remains, and to all appearance is now in the same state as on the day it was used ten years ago. You will have gathered from my previous report that in using the bitumen I had selected the most exposed portion of the wall, that is, on the paved slope of the stone-work between high-water spring tides and high-water neap tides, my object being to ascertain to what extent the bitumen would resist the heavy scouring process incessantly going on over the face of the rock paving. The result shows most conclusively that this heavy scouring process has much less effect on the bitumen than on the hard Kentish rag stone that we use for the paving on the face of the sea wall. From what I have seen of the almost imperishable nature of the bitumen, I should think that it would be invaluable for marine foundations, dock walls, piers of bridges, etc., one of the great advantages attending its use for marine works being that immediately after its application to the stones it sets firmly, so that the action of the next tide, even within the half-hour, produces no effect on it beyond increasing the firmness, causing the exposed surfaces to become quite indurated and yet tenacious, whereas Portland cement is constantly washed out immediately after its application, owing to the time it takes to set. This last feature of Portland cement is mostly shown in places affected by tides, or when bad weather supervenes ; and as the bitumen will take an enormous amount of gravel or other similar material without injury to its binding properties, the cost of the bitumen at anything like 70s. per ton would bear a strong contrast to the cost of Portland cement, while on the question of durability it scarcely admits of any comparison. I have used Portland cement on the sea wall to a considerable extent in the same way I used the bitumen ; the cost yard for yard for Portland cement was nearly double that of bitumen, and was all gone even in the most favorable positions, in a year or two ; not from a break up of the paving, but fairly scoured off and out of the joints of the stone paving, and gone. I should much like to have a few more tons of the bitumen. My idea is that it would be better to use it in a mass, to form a face by itself to protect the earth below ; but on this matter I will write to you again in a few weeks time.

A QUICKSILVER mine has been discovered in the district of Retiro, in the principal mountain range of Guija, State of Antioquia.

ON THE DUTY OF CORNISH AND OTHER PUMPING ENGINES.

From "The Artizan."

The differing features of the Cornish engine from other pumping engines are as follows :—1. It is generally worked at a high rate of expansion ; 2, there is a steam jacket attached to the cylinder ; the cylinder is covered with felt, and in addition to this, a covering of ashes or clay about 1 ft. thick, and then a covering of brickwork to prevent radiation, and there is a drain pipe from the jacket to carry away the water from the condensed steam to the boilers ; 3, the boilers and pipes are all arranged so that there is the least possible radiation of heat—the boilers being generally covered up with fine ashes or common clay. In three trials made with the engine to ascertain its duty, it was found that the effective duty varied from 4.4 lbs. per horse-power per hour to 5 lbs. When the balance-beam was attached and the arrangements completed, it was found that the effective duty was increased from 4.4 lbs. to 3.6 lbs., equal to a saving of 16 per cent., and which, taking the feed of water at 860 gals. per minute, would amount per annum to 420 lbs., and at 4s. per ton, to a saving of £80. Not only was there this saving, but also a steadier working of the engine.

The following table contains the results obtained in the work of 12 engines ; No. 1 being a Cornish engine :

No.	Dimensions of cylinder.	Gallons per minute.	Horse-power effective.	Effective duty in lbs. per horse-power per hour.	Indicated duty in lbs. per horse-power per hour.	Million lbs.	Cost per annum of coals per 100-horse power of effective duty.	Percentage effect.
1	70 in.	829	149.16	3.6	2.9	61.28	£283	81
2	77	1474	161.65	10.9	8.7	20 39	854	79
3	44	385	50 10	9 9	8.0	22.68	763	81
4	63½	1086	81.86	11.3	10.6	19.69	891	93
5	48	416	29.34	24.8	20.8	9 01	1940	83
6	82	191	69.29	28 5	—	7.78	2234	—
7	44	837	70.0	12.5	10.9	17.22	977	84
8	40⅜	785	71.36	16 9	13.9	13.05	1329	89
9	42	1460	98.03	10.6	—	—	849	84
10	52½	495	43.65	9.7	6 5	22 95	761	67
11	70	669	58 72	—	—	—	—	—
12	65½	324	54.16	27.4	—	6.27	2234	—

We find a total aggregate effective power of 1,030 horse-power applied, making an average duty of 14 lbs. per horse per hr. This we believe to be the average duty of the Newcastle district. Were a duty of 4 lbs. obtained, the saving in these engines alone would represent 40,000 tons of coal per annum, which, at 3s. per ton, would equal £6,000. We may safely assume the total horse-power of engines used for pumping water in the Newcastle district at about 10,000, and upon the above basis of saving we have a very momentous sum as the result. In many places coal may not be worth so much as 3s. per ton at the pit's mouth, but in the majority of cases it will very much exceed this.

We are too much inclined to think the coal at the colliery is of little or no value, and that the extra consumption of 10 lbs. or 12 lbs. per hour is not worth consideration. It must not, however, be forgotten that the fuel is not the only pecuniary part of the question, for additional consumption of coal means additional water, additional repairs, additional wear and tear, to say nothing of additional manual labor, and these in the aggregate are very serious items of cost. There is no doubt that more attention is being paid to these subjects than formerly, and we venture to predict that the time is not far distant when pumping and all other colliery engines will be erected with more regard to annual economy, and that the effective duty of 2 lbs. or 3 lbs. per horse power will be considered quite as important in them as it is now in London water works and in ocean steamships.

ON THE MODE OF WORKING COAL AND THE MECHANICAL APPLIANCES IN THE MIDLAND COAL-FIELDS.*

From "Engineering."

The author remarked in commencing, that one of the principal advantages of the practice of holding the annual meeting of the Institution in different localities was the opportunities which it afforded for the examination of the engineering features of the district, and particularly those in which the same end was accomplished by very different means. The last meeting was held in the northern coal-field, and much was seen of the modes of work there practised. The initial problem in all coal mining was the mode of dealing with the coal of the different strata which overlaid the seams and which imposed a statical pressure upon the new wrought seam in the ratio of its depth from the surface; this pressure being—roughly speaking—equal to about 1 lb. per square in. for each foot of such depth. There were two principles upon which this question could be dealt with, which when applied in practice might have very numerous modifications. In the early days of coal mining there did not appear to have been any intercourse between different mining districts, and it was somewhat remarkable, that whilst in some places the leading idea in the most ancient workings appeared to have been to work the coal in galleries and to support these by leaving pillars on either side of them, in many others the idea was to remove the coal entirely and to secure the necessary openings or working places along the edges of the solid seam by taking advantage of the resistance which the overlying rocks opposed to the vertical fracture in shearing. In some localities, therefore, methods of pillar work appeared to be indigenous, while in others the practice had always been to remove the whole of the coal at one operation, or, as it was commonly called, to work it "long-wall." This was the method of coal mining practised in the midland coal-fields, and the following is a brief description of the principles upon which it was based. In the actual working of a "long-wall" mine the first operation was to drive headways in the solid coal. When these had attained a sufficient length working places or stalls were started from the side of one of these, and the coal was removed in a series of slices parallel to the headway course. To support the roof of the working-places, timber was set, and a pack wall of lose stones was built up at regular intervals. As the faces advanced, the timber was withdrawn and the roof settled down—often without fracture—upon the packs. The roadways for the conveyance of the coal were carried at intervals of 20, 30, or 40 yds. between pairs of pack walls, and as the roof settled down and squeezed everything tight, the requisite height for the roadway was maintained by ripping or cutting up into the roof. The roadways, therefore, of a "long-wall" coal mine were carried through the goaf, or area where the coal had been wrought practically in the rock or other roof of the coal seam. As regarded the application of power for the underground haulage of coal, it seemed improbable that direct steam traction would ever be used except in a case where there was an arched roadway moderately level, and which could be provided with a distinct ventilation, a combination of circumstances that was not likely to occur often in practice. Attention might, therefore, be confined to stationary engines, driving ropes, or chains. Having referred to the method of hauling by "main tail" ropes, the author proceeded to consider the mechanical aspects of the question, and remark that in arranging any general system of underground haulage it was necessary to carry main roadways not merely on a level course, but with a rise or dip, or, indeed, in any direction which might be dictated by the position of the coal to be worked, in reference to the winding shafts. The average frictional resistance of wagon in collieries was given by the author as being $\frac{1}{50}$ of their weight, and it was stated that a falling gradient of 1 in 30 was sufficiently steep to enable full wagons when descending to overcome their own friction and haul up a train of empty wagons also. The author's remarks pointed to the conclusion that the haulage of *trains* of wagons in collieries was less advantageous in many

* Abstract of a paper read before the Institution of Mechanical Engineers, at Nottingham, on the 2d inst., by Mr. Geo. Fowler.

respects than the practice of attaching the wagons singly to an endless chain at intervals of 20 yds. or so. The endless chain would be driven by clip drums, and by this plan the wagons themselves would form rolling supports for the chain, and carry it without much additional friction. An application of this system in a mine in the neighborhood of Nottingham was described by the author, the chain in this case being merely allowed to rest in a kind of hook on the side of each wagon to be moved. The tendency to rust, caused by this side attachment, was stated to be counteracted by the tension on the rope, and it was pointed out that in this system the undulations of the road produced no effect so long as the series of wagons was continuous.

Proceeding to consider the lifting of the coal, the author next pointed out that although it is possible to balance accurately the weight of the ropes tubs, etc., yet the application of steam power to the raising of coal is not favorable to the realization of a high useful effect on account of the great weights which have to be brought into rapid motion, and subsequently into a state of rest. In deep shafts the weight of the ropes exceeds the net loads, and it is usual to balance them either by the use of a special drum and balance chain, or by coiling them on conical drums of such pitch that the moments of load with empty cages are at every portion of the engine approximately the same. The actual working of an engine consists therefore of a rapid series of motions in opposite directions. In raising a large tonnage of coal each journey of the cages is effected in less than a minute, and each time it is necessary to put the machinery in motion and stop it within that space of time. Three examples were given by the author, of different methods of working. Engine No. 1 was stated to be a vertical high-pressure engine with 40-in. cylinder and 5 ft. stroke, fitted with 12 ft. flat rope drum and small balance drum, the action of the balance being to assist the engine until the cages pass and to absorb power during the remainder of the run. Engines No. 2 are a pair of horizontal high-pressure engines with 36-in. cylinders and 6 ft. stroke fitted with round rope conical drums, the cone increasing from 20 ft. to 30 ft. in diameter. Engines No. 3 are a pair of horizontal engines of the same dimensions as No. 2, but with 14 ft. wrought-iron flat rope drums without counterbalance. In the case of engine No. 1, the engine man works with the throttle valve open, "hands" the engine fairly started, and then throws the valve gear into action, while at the end of the run he detaches the valve gear and meets the piston with steam on its opposite side. In No. 2 the engine man also works with an open throttle and regulates the engine by this link motion, reversing it at the end of the run; a steam brake being provided for use in case of need. In engine No. 3 the steam and exhaust valves are all worked by link motion and the engine is worked in full gear, the throttle valve being gradually closed towards the end of the run so that a partial vacuum is framed behind the piston, the engine remaining in forward gear.

In the cases above mentioned the loads are drawn from depths of 220, 470, and 415 yards in 30, 45, and 45 seconds respectively, the main speed of the cages being thus: 22, 27, and 27 ft. per second; but as about one-half of the revolutions are either accelerating or diminishing the velocity, the maximum speeds may be taken as 27, 36, and 36 ft. per second. The weight in motion may be estimated as follows:

	No. 1. tons.	No. 2. tons.	No. 3. tons.
Flywheel and drums	15	45	12
Ropes	4	6	7
Cages, coal, and tubs	6	4	8
Pulleys	2	6	3
	27	61	30

Some of the parts move faster, and others slower than the coal, but the mean speed of the whole may be taken as equal to that of the latter. Thus the power expended in putting the masses into motion at the velocities named, will be:

	No. 1.	No. 2.	No. 3.
Number of foot-pounds of work required	689,472	2,732,800	1,344,000
Time during which the above power has to be developed	½ min.	¾ min.	¾ min.
Equivalent effective horse power to be developed by engine	42 H. P.	110 H. P.	54 H. P.

The author then directed attention to the different modes in which the "work" accumulated in the moving mass was disposed of during the latter part of the "run" in the three cases under consideration, engine No. 2 pumping back steam

(drawn from a long exhaust pipe) back into the boiler. The author further pointed out that if the engine instead of having to develop at the commencement of each run a power greatly in excess of the average, had uniform or nearly uniform work to do throughout each lift, a much smaller engine could be used and there would be a saving of engine and boiler room effected. The question of economy of fuel the author regarded as being a secondary one in such cases. To attain the desired end of giving the engine approximately uniform work to do, the author recommended the employment of conical drums having their contour lines so far modified from those usually adopted that during the first two or three strokes of each run scarcely any lifting would be done, almost the whole power of the engine being employed in putting the machinery into motion. The contour, moreover, would be such that during the middle strokes the engine will lift the load and overcome the friction, and that in the last two or three strokes the leverage of the load will be so much increased that the momentum will be usefully expended in assisting the engine to complete the lift. In the apparatus which the author described in connection with this drum (which is in use in a colliery in the neighborhood), it was desirable for the purposes of ventilation to reduce the area of the cages, to avoid impeding the ventilation. So they were made with four platforms, each holding one ton of coal. To save time in emptying and loading, these platforms or decks were furnished with two points of unloading and loading, so that they could be all loaded and emptied with one change in the position of the cages. The time occupied is not more than twenty seconds, and the engine can raise 180 wagons of coal per hour.

EXPLOSIVE POWER OF NITRO-GLYCERINE.

From "The American Chemist."

A measure containing one cubic foot will hold 796 oz. of blasting powder, and 997.1 oz. of water; or, in other words, the specific gravity of blasting powder, as it is used, is about 0.8. This of course takes in the interstices, which are filled with air, but as we do not use the powder in a solid lump, this is, for practical purposes, the specific gravity of blasting powder. Now the specific gravity of nitro-glycerine is 1.6. Therefore, bulk for bulk, if the explosive power were the same in a given mass, as prepared for blasting, the nitro-glycerine would have twice the power.

In reality the following are the volumes of gas generated by each respectively in explosion:

One volume of powder which is considered as most effective, produces:

Carbonic acid gas	221.4 vols.
Nitrogen	74.6 vols.
Therefore 1 vol. becomes	296.0 vols.

Of another kind of powder, which explodes with the gases at a lower temperature, one volume produces:

Carbonic oxide	391 vols.
Nitrogen	66 vols.
One volume becomes	457 vols.

One volume of nitro-glycerine produces:

Carbonic acid gas	469 vols.
Water at 100° C	554 vols.
Oxygen	39 vols.
Nitrogen	236 vols.
One volume becomes	1,298 vols.

These volumes are given at 0 deg. C, in the case of water at the lowest temperature, at which it exists as a gas. Now for 1,000 deg. C. (which is supposed to be the temperature of the gunpowder gases at the instant of explosion), using the formula $V^1 = V(1 + t K)$, and taking $K = 0.00366$ and $t = 1{,}000$ deg., these volumes will be about five times as great as those given above, *i. e.:*

1,480 for carbonic acid powder.

2,285 for the carbonic oxide powder.

If now we suppose the temperature of the explosion of nitro-glycerine to be 2000 deg. C , and make use of the same formula, we multiply the 554 volumes of water by $(1 \times 1900 \times .00366)$, since these volumes are given at 100 deg. C. We also multiply the remaining 744 volumes by $(1 + 2000 + .00366)$ and add the products together. The result shows the volume of the mixed gases to be about 10,607 times the original volume of the substance ; and

as the specified gravity of the nitro-glycerine, as used, is twice that of the powder as used; or, in other words, in a given compass of nitro-glycerine there is twice as much explosive material as there is in the same volume of gunpowder, we may multiply this result by 2 to show the relative power, which brings this up to 21,214, or about 10 times as large a production of mixed gases for the nitro-glycerine as for the gunpowder which produces the mixed gases in largest amount.

Still 13 times is claimed by the advocates of nitro-glycerine. If this is so, the discrepancy between the temperature of the explosions must be greater than here assumed.

WORKING LOAD OF IRON STRUCTURES.

From "The Engineer."

The proportion which the working load of any cast or wrought-iron structure should bear to the load that would fracture it—usually termed its breaking weight—is a question upon which engineers are by no means unanimous. It is true that there is not that flagrant discrepancy now existing that prevailed many years ago, when the Royal Commission was appointed to inquire into the application of iron to railway purposes ; but still the point remains practically as undecided as ever. At that time the two extreme ratios given in evidence before the Commissioners varied from one-third to one-tenth of the ultimate strength of the material. To a certain extent the fiat of the Board of Trade has extinguished all discussion on the matter among those who are engaged in designing railway structures of any description whatever. It signifies nothing what may be the private opinion of the engineer, or the results of his own actual experience. He must not exceed the prescribed allowance of four or five tons per square inch of sectional area, as the case may be ; and to this inabsolute standard he must tacitly submit. There may, in some instances, be circumstances which might cause this dictum to press somewhat heavily and unfairly upon both the design and the designer, but it is impossible to avoid acknowledging that, upon the whole, the rule is sound and the limit judicious. It cannot be concealed that, with all the skill and precaution employed in testing the strength and quality of the materials which are used by engineers, it is not always possible to detect a flaw. Bars, plates, aud girders of iron have sometimes, after being tested, yielded under a weight considerably smaller than that which they previously sustained without any appreciable signs of incipient weakness. When, moreover, it is kept in view that the lives and safety of the public are intimately concerned in the matter, the wisdom—in fact, the necessity—of fixing a standard that shall be well within the limits of safety becomes at once apparent. The question, however, may fairly arise—Is this limit always a safe one? May it not occasionally be minus as well as plus ; and if holding good for the structure as a whole, may it not fail when applied to the separate and individual members composing that structure? This will be considered as we proceed.

In establishing a proportion between the safe or working load and the breaking weight of an iron girder, for example, it is manifest that the conditions of safety originally assumed to exist will only do so under precisely similar circumstances. Or, to put it in other words, if this ratio or limit for the statical working load be derived from a statical breaking weight, it cannot be expected to hold good when the statical load in practice is replaced by one of a dynamical and impactive character. When the conditions are altered which existed when the standard was created, it clearly is no longer applicable to the case in point. Consequently, if the strength of a bridge be sufficient to carry safely a statical or dead load, it is not necessarily sufficient to carry a rolling or live weight of the same amount with equal impunity. A bridge when it is merely supporting its own weight, and is what is termed doing nothing, is exposed to the minimum amount of statical strain. When traversed by ordinary loads it is undergoing its average dynamical strain, and when it is covered by as many locomotives as

can be got together upon it, the statical strain is the maximum any engineer or inspecting officer can possibly devise. If all these engines be run over it at their greatest possible velocity, the resulting effort upon it may be regarded as the greatest statical or dynamical strain that the structure could ever be subject to. It might be fairly asked, suppose each of these methods of loading, or rather of inducing strain, were pushed to a degree that caused the failure of the bridge, from which of them should the ratio or limit be derived? The answer will be, obviously, from the last. But is it so? has the standard been thus derived? If a girder be broken by a dead weight, or by a live load, that is a weight acting upon it with a certain degree of impact, in both instances the result is known, but there the identity terminates. In the former case the fracture is known to be due, and due solely, to one cause; in the latter it is also known to be due to a combination of two causes, weight and impact; but the exact part that each plays in the operation remains undetermined. The question is simply an "indeterminate equation," two unknown quantities being given, and only one equation from which to eliminate their value. Thus, if we consider the absolute strain necessary to fracture a bar or girder to be a constant, independently of the manner in which that strain is inflicted, the sum of the component forces producing that strain will also be a constant although their individual effect is unknown. Suppose a girder of a given length to be broken by a certain dead weight uniformly distributed over it, we also know that it will be equally broken by a certain live load or a certain weight caused to travel over it at a given velocity. But assuming a velocity, we cannot tell what the minimum weight would be; nor, assuming a weight, can the minimum velocity be predicted. Considering the breaking live load of a girder as compounded of the weight and the velocity or force of impact, it cannot be estimated *a priori*, nor, when once ascertained by actual experiment, can it be divided into its components. A constant weight travelling at different velocities over a girder will affect it nearly in proportion to the velocity, as can be plainly proved by observing the deflection; but, if the weight and velocity be varied inversely, the deflection will not be the same. If a weight of one ton be caused to traverse a bridge at a certain velocity and produce a certain deflection, it does not follow that a weight of two tons travelling at half that velocity will give rise to the same amount of deflection. The ratio of the moving weight to the insistent weight of the bridge must be introduced here, and complicates the question. Small bridges, therefore, are more exposed than large ones to this disturbing cause. Practically, the real source of danger to railway bridges from the passage over them of heavy loads travelling at a high velocity, is to be traced to a bad state of the permanent way. The condition of the road has been shown by experiments made by Mr. Hawkshaw, to very materially influence the amount of deflection produced by rapidly moving loads. From these observations it is readily perceptible that it is quite impossible to tell whether parts at least of a bridge are not exposed to a greater working strain than that prescribed by the regulations of the Board of Trade.

A very curious result, and one very much affecting the strength of girders, was elicited in the experiments undertaken by the "Iron Commissioners" in their inquiry into the mechanical effects of the impact of heavy bodies on beams. It was found that bars of cast-iron of the same length and weight struck horizontally by the same ball, offered the same resistance to impact, whatever was the form of their transverse section, provided the sectional area was constant. A bar 6 in. by $1\frac{1}{2}$ in., supported upon bearings 14 ft. apart, was broken by the same magnitude of blow whether it was placed flat or on edge, and a similar force was required to fracture another bar, 3 in. square, which had therefore a different shape, but the same sectional area and weight as the former. It is not stated whether the same results obtained with bars of wrought-iron, but the inference to be drawn with respect to beams and girders of cost-iron is obvious. The strength of a girder, whether subjected to a dead or live load, is always considered to be directly as the depth, and the calculations for its proportions and dimensions are based upon that assumption. Supposing this to hold, as it does, for a statical load, the experiments alluded to lead us to infer that it does not apply to cases of dynamical loads. Instead of

the strength being directly as the depth, that quantity does not even enter into the calculation. Viewing the matter in this light, therefore, we require a different formula for calculating the strength of girders exposed to statical and dynamical loads respectively. To obtain the second of these it will be necessary to institute some experiments on a large scale, and actually break some beams and girders by a rolling load, as was done with the small cast-iron bars. There is a great and an acknowledged want of further information in connection with this whole subject. No accurate idea can be formed of the strength of any combination of parts by knowing merely that of the components; and so many new forms, sections, and arrangements of iron have been introduced in construction since the existing experiments were undertaken, that there is no reliable data to proceed upon. Had the well-known Britannia model tube been broken once or twice by a dynamical load, in addition to the fractures effected by statical loads, the results would have furnished a very desirable addendum to the valuable fund of scientific and practical information contained in Mr. Clark's book. There is little use in carrying experiments half way. Estimates of the ultimate strength of a beam or girder based upon deductions f om its deflection under certain weights—whether statical or dynamical—are neither satisfactory nor conclusive. Nothing short of the actual fracture of model tubes, beams, or girders, is to be relied upon as a datum for calculation. As an instance of the great dearth of knowledge possessed upon this point we may select open web or lattice girders. There is not a single experiment extant respecting the ultimate strength of this type of structure. We do not consider the one made by Sir W. Fairbairn several years ago worthy of the name. The specimen was designed in defiance of all the laws that are now known to apply to the principle, and was a fit example of the unscientific and crude designs that characterized the introduction of the lattice system. Under these circumstances it is not to be wondered at that the result was not in favor of the adoption of the open web type of girder, and it is not improbable that it may have in some measure contributed to retarding the development of a principle the soundness and economy of which is now universally recognized by engineers.

FIRE-PROOF STRUCTURES.

From "The Building News."

Notwithstanding that we live in a complete "age of iron," but very little use, comparatively, is made of that material in our buildings towards counteracting the effects of fire. It is true that in the majority of our new public structures timber in balk has been to a great extent replaced by cast and wrought-iron, and care is generally taken that the staircases and floors are constructed so as to be fire-proof, or nearly so. Regard is also had to these details in most of the gigantic warehouses and stores that are erected by our merchant princes. But, including all these and many more examples, the total yet falls far short of what it should amount to in a city in which fires are almost of daily occurrence. It is unquestionably more costly to build structures of fire-proof materials than of others that are not so constituted, and this is the reason why the principle is not carried into practice in buildings of secondary importance, where the first cost is the only feature considered worthy of attention. It is impossible to expect that private builders will ever introduce the fire-proof system into their trade until it be rendered obligatory by legislation. This is a step which no one can say would at the present be either fair or judicious. It must not be forgotten that buildings and houses are erected now upon much shorter leases than formerly prevailed, and there is consequently neither the inducement nor the necessity for building them in so durable a manner. We have heard it stated on very good authority that a nobleman who owns a large amount of metropolitan property will not grant a building lease on the land for more than 25 years. No one in his senses would build a fire-proof structure on a property subject to such con-

ditions, nor could it ever be attempted by the Legislature to enforce a measure of that nature, unless at the same time some radical change was introduced in the law of fixtures and dilapidations. The reversion of the tenants' property to the lord of the soil becomes too expensive an affair when durability and permanency are its distinguishing characteristics.

In all buildings the staircases, floors, and roofs are the chief elements of danger and destruction when exposed to fire. All these in ordinary dwelling-houses, and even in structures of a far more pretentious nature, are usually constructed of that inflammable material—wood. It can perhaps scarcely be advanced, so far as the safe escape of the occupants of a house in flames is regarded, that there is an absolute necessity for the roof to be fire-proof, but there is no doubt respecting the floors and staircases, or, at the very least, of the latter of these. An iron or stone staircase would, in our opinion, prove a far better mode of egress from a burning house than that which is termed, by mistake, a fire escape. Granting for the moment that this part of the question is not yet quite ripe for compulsory legislative enactments, there are undoubedly numerous instances in which the fire-proof principle in its full integrity should be rigidly enforced. By the above phrase we mean that it should not be applied to merely portions of a building, but should include the whole structure. It is not enough in these cases to leave the matter in the hands of owners of property or tenants of wharves and warehouses; for suppose one proprietor to place a large store of exceedingly inflammable and combustible goods and merchandise under a fire-proof building, and his next neighbor to keep his stock of similar commodities in wooden sheds—timber magazines—the former is perfectly at the mercy of the latter. Among the instances to which we have alluded as calling for the interference of the Legislature for the compulsory adoption of the fire-proof principle of construction, may be mentioned that of the gigantic stores, warehouses, and other erections lining the shores of our great national docks. It was but yesterday that property to the value of over £20,000 was either consumed or destroyed by a fire that broke out in the Victoria Docks. The conflagration took its rise in one of the timber warehouses used for storing bales of jute. The warehouse measured 150 ft. in length and breadth, and contained no less than 3,000 bales of jute. Fortunately, by dint of great exertion, the fire was confined to the single building, but had it spread to the contiguous ones the loss of property would have been enormous. It will possibly be asserted by some that although a building may be constructed of fire-proof materials, that will not prevent the contents from catching fire from internal causes. This is true to some extent, no doubt, for if a light were applied to a quantity of jute or other inflammable description of goods, the nature of the building that contained it would not prevent it being set on fire. But if the structure were fire-proof, it should contain in itself no element of destruction from fire, and also should prevent the possibility of it being communicated to the interior from causes of an external nature. As we proceed, it will be seen that so-called fire-proof structures are sometimes by no means faithful specimens of that principle. It may with truth be said, that excepting the desirability of saving the lives of inmates by the adoption of iron or stone floors and staircases, there is not the slightest real utility or immunity from danger obtained by making part of a building proof against fire. It is simply a "doing of things by halves," a course of action that never has and never will attain to any permanent advantage.

Speaking from a professional point of view, the three principal subdivisions of a fire-proof structure are the roof, the floor or floors, and the side walls, or carcass. Of these, considered separately, the first is the most common. In fact, any roof that is constructed of iron trussing, as a very large number are at present, in all cases where the span exceeds very limited dimensions, is, *per se*, almost fire proof, unless it be boarded over before the outer covering of slates or other material be put on. The necessity for using boards, and thus doing away, as it were, with the very principle of the roof, is, in some exceptional instances, absolutely unavoidable, as it becomes imperative to have a "cool" covering at all hazards. Even when the covering is not supplemented by boarding, unless the whole of the building be fire-proof, a conflagration, although it cannot actually consume, yet nearly invariably

destroys the roof. That cast-iron columns, beams, and girders are not fit to be erected again in the same position, was amply demonstrated by the unfortunate burning of a portion of the Crystal Palace. The carcass of this magnificent edifice is fire-proof, so far as that term applies to fire originating in any of its actual component parts, but that did not prevent the floor, which is an immense area of planking, from catching the fiery infection from the over-heated pipes and flues. A communication was rapidly established through the agency of the tall tropical plants and the various beautiful courts, to the glass of the roof and sides, which could melt, if it could not inflame; and but for the fact that the wind was favorable to the extinction of the conflagration, there would not have been in the whole Palace "one column left on another." Had the floor of the Palace being of concrete it might not have absolutely prevented the burning that took place, but it would undoubtedly have both mitigated and retarded its course. It is very doubtful whether wrought-iron will withstand with impunity the extreme opposite effects of fire and water, but there is no question that any cast-iron, forming portion of a building that has been through an ordeal of that description, is utterly unsafe to be again employed for any purpose of construction. It is only fit for the melting pot. At the same time we have very strong suspicions that many of the columns and joists forming portions of the *debris* of the Crystal Palace fire, which were sold by auction or disposed of by private contract, have been placed in positions where they are still doing duty. To proceed still further, there are not wanting instances in which buildings erected in every sense upon a fire-proof principle have been as totally destroyed as if they had been constructed of the most inflammable materials. The latest example is one which happened about a week ago. Some very extensive flour-mills, scarcely four miles from the town of Cork, were entirely demolished by this cause for the second time. After the first occurrence, it was determined by the Company to reconstruct the mills on the fire-proof system, which had not been adopted in the first instance, in order to obviate the danger of a second conflagration. No pains nor expense were spared to insure this object, but all the precautions failed to avert the result, which has reduced the whole premises to a mass of ruins, including some very powerful and valuable machinery. In the face of these facts, the construction of a really fire-proof building appears to be a question yet to be solved, and the prospect does not seem very encouraging. While there are unquestionably some fire-proof systems of a *bona fide* reliable nature, there are a large number so called which are worthless, as well by the materials used as the manner in which they are disposed and put together. There is a great deal yet to be done in this particular branch of constructive art. At present we have only made a commencement, and not a very good one either. There is plenty of room for improvement, and we do not doubt that it will soon become manifest, especially if the Legislature turns its attention to so important a subject, which is so vitally connected with the safety and welfare of all great cities.

THE Paterson "Press" says: "The reconstruction of the Rogers Locomotive and Machine Works will not be carried any further this year. The immense new mill lately erected is gradually getting into operation, and in a few months will probably be entirely in use. It is driven by one of the finest overshot wheels in the city—an 80-horse power affair. The next rebuilding, it is thought, will be at the corner of Market and Spruce streets, but that will not be started before next spring."

QUALITY OF ICE.—The French steamship company (Les Messageries Imperiales) having to ship a quantity of ice to Suez for the use of its steamers in the Indian ocean, and desiring to find the best quality for their purpose, subjected 220 pounds of several kinds to the same conditions of temperature, with the following results:—Natural ice from Switzerland lasted 107 hours; natural ice from Norway, 115 hours; artificial ice, made by the Carre machine, 130 hours; natural ice from Boston, Mass., 138 hours; artificial ice, made by the Tellier machine, 144 hours. Artificial ice, then, appears to be as solid as natural ice.

RAIL MENDING.

From "Engineering."

The days of magnificence and prodigality in the management of the funds of even our best paying railways have long since departed. Gradually melting dividends sooner or later failed not to rouse even the most confiding and befogged class of shareholders, and the wail of their *coronach* over departed incomes summoned to their rescue a whole host of railway doctors, and possibly a still more imposing host of quacks. The first incidental advantage of this movement was to supply a healthy amount of light and ventilation to the close bureaux where railway affairs were doctored; and, beyond that, the knowledge was soon attained that those who promised most performed the least, and that, not in heroic remedies, but in the exercise of economy in innumerable minutiæ, was the improvement of the financial state of railways to be sought.

The attainment of this preliminary step at once started railway economists on a fruitful voyage of discovery. A few steps forward disclosed to them the existence of a wide field for the ingenuity of inventors, in the development of improvements calculated to reduce the enormous current expenses of that all-essential portion of every railway—the iron road itself. It appears hardly credible at first that one of our railway companies alone should have expended upwards of £2,000,000 sterling in mending its roads, but such is the indisputable fact. Under that head the annual expenditure of the London and North-Western Company is over £100,000; of the North-Eastern some £60,000 to £70,000; and of the Great Northern nearly £50,000 sterling. Upon heavily worked portions of a railway, 20s. per day is not too high an estimate of the tax upon the receipts to maintain each mile of line in proper condition for traffic; and on average lines this tax would seldom be reduced more than 50 per cent.

The cause of this enormous charge is not far to seek; it is at once traceable to the inherent defects of the iron rails themselves. One of our best authorities, Mr. Menelaus, the manager of the largest iron works in this kingdom, did not hesitate to assert, in the presence of the largest muster of ironmasters ever assembled at the Institution of Civil Engineers, that it was commercially impossible to manufacture an iron rail which would satisfactorily sustain the present traffic of many of our lines for any reasonable length of time. The truth of this proposition may be made apparent, even to railway directors, without any technical knowledge, if we consider for a moment the requirements in a rail on the one hand, and the process of its manufacture on the other.

A perfect iron rail will be one which is sufficiently strong in every direction, and which, consequently, will remain serviceable until the head shall be fairly worn away by abrasion. Now, as far as the resistance to crushing under the rolling wheels is considered, we know that no trouble is to be apprehended in the direction of the length of the rail; for each particle of metal is there kept up to its work by its neighbors; and as it cannot escape, the particle cannot be crushed—for the same reason that water cannot be "crushed" in an hydraulic press. If crushing occur in a rail, then, the particles must move laterally; or, in other words, the head of the rail must widen out. To resist this tendency great strength is required in the metal in a direction at right angles to the length of the rail; and to attain this strength in wrought iron, as in wood, the fibres should run in the same direction. To obviate the frequent splitting of the longitudinal sleepers in the Great Western road, short pieces of wood are inserted crossways between the rail and sleeper; how to remedy the same defect in wrought-iron rails is not so apparent.

We require strength, and consequently, at least some pretence of fibre, at right angles to the length of a rail, but what do we get in practice? By the ordinary process of manufacture, the rail pile has a top and botton slab of No. 2 iron roughed down from puddle bars, so that every particle of metal in the wearing portion of the rail has undergone the following processes: The original fibreless bloom has been shingled or hammered, and passed through the puddling train, by which every particle of iron has been extended to some ten times its original length in one direction. The resulting puddle bars

have been cut, piled again, and again extended, in going through the rolls, to some six times their length. The slab so formed has been extended once more some ten times in rolling the finished rail, so that every particle of iron in the head of the rail has been elongated in one direction some six hundred times, and reduced to a corresponding extent in the other. The finished rail then consists of a bundle of fibres, and when we consider all the exigencies of practice, and the difficulties in completely excluding foreign bodies from the numerous layers of bars in the several piles, we cannot be surprised that an iron rail is frequently stigmatized as a bundle of wire cemented together with cinder. Changes may be rung in the mode of manufacture, hammered slabs may be substituted for puddle bars, and the fibre may, to a certain extent, be modified by cross piling, but the broad fact remains, as stated by Mr. Menelaus, that it is commercially impossible to make a perfect iron rail.

Steel rails, of course, meet all the requirements of practice, but the great mass of railways in the world are still iron roads. This being so, the question of paramount interest to all railway authorities is how to make the best of the existing condition of things. A satisfactory answer to this question has been obtained on the other side of the Atlantic, and the solution of the apparently complex problem is so simple and complete that the only wonder is that it was not stumbled upon before.

Mr. Baines, a Canadian, tells us to mend our rails, not to sell them for old iron because they are crushed or split for a few feet in one or two places, whilst the remainder of the rail is as serviceable as ever. "Put on a patch," says Mr. Baines.

Now, were not the imperial days of railway management, as we have already maintained, for ever vanished, the suggestion of a patched rail would no doubt have been treated with withering contempt, as a thing to be mentioned only in the same breath with chiffonniers, footless hose, and amorphous hats. But at present, notwithstanding Lord Chesterfield's dictum, that a man of fashion never has recourse to proverbs and vulgar aphorisms, in the maintenance of the way and works of railways it is the fashion to act rigidly upon the maxim that "a stitch in time saves nine." The system of repairing rails invented by Mr. Baines, enables us to do this in the instance of the most important item in railway maintenance—the rails themselves.

We cannot reasonably expect a bundle of particles of metal, elongated as we have shown to some six hundred times their original length, to be in many instances welded uniformly well throughout their entire length, and in practice we do find a defective weld in almost every rail. Under traffic this weak weld is burst open by the hammering of the passing wheels, and the rail becomes more or less split and indented. The rail may be, and generally is, practically intact elsewhere, but this one weak spot cannot be eradicated, so the rail is discarded, to afford another illustration of the paradoxical proverb applied by the Greeks to law arbitration, *et hoc genus omne*—that the half is better than the whole.

Now the mode of procedure in such an instance, in Canada and the United States, where Mr. Baines's system has been in full operation for some years, is so simple, that the sacrifice of the rail becomes almost culpable. The apparatus invented by Mr. Baines has already been fully illustrated and described in this journal, vol. vii., p. 236, but the *rationale* of the process may be exhibited in a few lines: A piece of bar iron of the requisite length is placed upon the damaged portion of the rail, and, together with that portion, is raised to a welding heat in a furnace specially designed for the purpose. At the proper moment the rail with its patch is withdrawn, and the heated portion passed through rolls corresponding to the finished section of the rail, by which means the rail is restored to its original form at the damaged point, and its inherent weakness there is completely remedied by the addition of the new piece of iron, and by the rewelding of the originally imperfect weld which induced the damage. It is no matter for surprise, therefore, that a mended rail is rarely found to yield again at the same point. The patch becomes an integral part of the rail, and no traces of the weld are visible upon the closest inspection of a cross section, fractured either by steady pressure or by a blow.

At the present time, six thousand miles of railway are enjoying the benefits of this invention. The Great Western of Canada were the first to try the system, and after

three years' test they have just erected a mill at their own cost to repair the rails upon 300 miles of line, for which they pay royalty up to £10 per mile. The Chicago North-Western have 3 mills finished or in progress, to serve their 1,800 miles of line, and many other American lines are availing themselves of the proved advantages of Mr. Baines's invention.

An experimental mill is now in operation in a small back yard, not 100 miles from Charing-cross; although anything but imposing in appearance, it is stated to be equal to the repairing of the rails on 250 miles of line, when it would effect an estimated saving to the Company using it of £5,000 yearly on a capital expenditure of about £3,000. Test rails are now being repaired for the London, Chatham, and Dover, and other companies. No doubt there is ample scope for the development of the system in this country, since, notwithstanding our exceptional national advantages, the cost of re-rolling rails must be at least ten times that for which they can be repaired. In India, where thousands of tons of rails are lying in purposeless stacks, the adoption of Mr. Baines's system, or something analogous to it, has become a necessity.

THE APPLICATION OF THE HOT BLAST TO BLOWPIPE PURPOSES, AND THE PROPOSED SUBSTITUTION OF HEATED AIR FOR OXYGEN IN THE PRODUCTION OF CERTAIN THERMAL AND ILLUMINATING EFFECTS.

By W. SKEY, Analyst to the Geological Survey of New Zealand.

From "The Chemical News."

The useful and well-known effects of the hot blast, in the process of iron smelting, has induced me to try and extend it profitably to other purposes, beyond that which prompted its application in the present instance. My experiments, as yet, have been confined to testing the effects of substituting a hot blast for a cold one, as hitherto used, for the production of the well-known blowpipe flame; a flame so produced will be expected to have its thermal and illuminating effects augmented, but scarcely, perhaps, to that degree which experiment has demonstrated. I had better state, at the outset, those particulars which it is necessary to know, before relating the results. The temperature of the blast was, approximately, 500 deg. Fahr.; the diameter of the jet, regulating its issue, was 1-30th of an inch; the combustible for receiving the blast was stearine. This flame manifested a very marked superiority over the common blowpipe flame—substances difficult to fuse in the latter, magnetite, potash, felspar, mica, readily yielded under these circumstances; while thick glass tubes, half an inch in diameter, and hard German glass tubes, were tractable to an eminent degree. Carrying my test experiments still further, I found several substances, for the fusion of which the oxyhydrogen flame, or some equivalent of it in heating power, is said to be indispensable, also yielded before the blowpipe flame thus urged; for instance, platinum, pipe-clay, fire-clay, agate, opal, flint. Several samples of each were tried, and always with the same results; it could not well be, therefore, that the fusibility of any of these substances was due to the accidental presence of foreign matter, in more than usual quantity. The platinum was the common platinum foil, also a sample prepared especially for the purpose; the only impurity found in it was iron, as traces, communicated to it in the act of forging; possibly minute quantities of some of the other metals of the platinum series might be present, but they would rather tend to increase its infusibility than otherwise. Alumina only appeared to vitrify; while, after numerous trials with crystallized quartz, I could not succeed in fusing it to a globule; thin splinters, however, curled round upon themselves, like scolezite, and ultimately assumed a glazee appearance, clearly showing that the melting-point was all but reached. It appears, from this, that a very small amount of some foreign substances exercises a marked effect upon the fusibility of silica, agate, opal, etc., being only a little less pure than rock crystal,

though so readily fusible in this flame. Regarding the illuminating power of the flame so produced, when allowed to impinge upon a solid substance, such as lime or magnesia, it was not only more intense (as would be expected), but the volume of incandescent matter was largely increased. Before I proceed to urge the further use of hot air for combustion, where high temperatures are necessary, I wish to call attention to the fact, that the temperature of the flame, which I have hitherto worked with, can be largely and economically increased by increasing that of the blast; this can easily be done to a threefold extent. By substituting heated hydrogen (or burnt coal-gas), I have also realized all the effects just instanced, with greater rapidity and decision; but the great diffusiveness of this gas, especially when heated, has prevented me, as yet, carrying the experiments further.

While on the subject of heating both combustibles (at least, both the substances which take part in these combustions), I cannot refrain from remarking how easily the temperature of the oxyhydrogen flame, even, could be increased in this manner—the gases would, of course, have to be heated prior to contact. Upon their more vigorous diffusiveness, when rarefied, I should rely for that solidity of flame so necessary where the communication of very high temperature is desired. The jets regulating the issue of the gases would have to be very fine. Proceeding now to the next part of this subject: the result of these experiments, instanced, urge me to recommend, for trial, the substitution of heated air for oxygen, in most of those cases where this gas is now employed in conjunction with hydrogen or other combustible matter, as a generator of heat of light; for instance —1. In the metallurgy of platinum, that part of it where the metal has to be fused; also in soldering platinum stills for sulphuric acid works. 2. The fusion of alumina in the manufacture of certain gems. 3. In the production of the Drummond and Bude lights. The fusion of platinum and alumina is now effected by the oxyhydrogen flame. Relative to the competency of heated air to perform the part of cold oxygen in the production of such intense lights as these (the Drummond and the Bude), I think this can be demonstrated, almost to a certainty, in the following way:

Thus, the flame employed in these investigations has certainly a minimum temperature of 4595 deg. Fahr., since this is the fusing point of platinum, the substance most easily fused of all those I have tried that are infusible in the common flame; doubtless the temperature is considerably higher, but I will take these figures. On the other hand, the actual temperature of the lime, when the Drummond light is in operation, is (on the authority of Tyndall) only 2000 deg. C. = 3632 deg. Fahr.; hence this flame has an excess of temperature over that of the incandescent lime equal to 964 deg. Fahr., a pretty good margin for loss, surely sufficient if properly economized; but as I have already shown, this excess of temperature can be largely increased. In view of the greater controllability of the proposed substitute, the absence of all danger in its use, its not requiring chemical preparation, and its cheapness compared with oxygen; upon these several points, respectively, the question should be properly tested. Besides the substitution of oxygen urged above, the possible fusion of the purer clays and certain silicas, etc., in a ready and economical manner, may induce the further utilization of these substances, while in experimental chemistry, the facility with which such high temperatures can be attained and kept up may lead, among other things, to some cheaper way of extracting certain metals from their oxides—for instance, from alumina or clay.

On reviewing these results, it does seem not a little singular that a difference of not more than 500 deg. Fahr. as the temperature of the blast should make the difference between the fusibility and infusibility, of such substances as platina, agate, fire-clay, etc., in the blowpipe flame. It will be recollected, however, that the blast has, in this case, not only taken up the heat required to raise a single volume of it to this temperature, but another portion of heat has to be taken up in a latent form, as the air expanded—consumed as it were in lifting against the atmospheric pressure; this may be represented sufficiently well for us, by assuming the temperature of the blast, kept to its normal volume, at 700 deg. Fahr. This is as yet, however, but a very slight addition to

produce results, which so nearly approximate to those obtainable by the oxyhydrogen flame, seeing the latter has an estimated temperature of 14,000 to 15,500 deg. Fahrenheit, while that of the present method does not much exceed 5,000 deg. Fahrenheit. The gap, as far as effects are concerned, is narrowed so much, and in a manner so unexpected, by the results here given, that one is naturally prompted to inquire whether the assigned temperature of the oxyhydrogen flame has been obtained by direct experiment, or by calculations, based upon the ascertained temperature of other flames. The temperature as calculated, indirectly, in this last way, certainly furnishes us with figures remarkably close to those just quoted. In reference to this important point, I beg to call attention to a notice which appeared in the "Chemical News," relative to the imperfect combustion of certain gases at high temperatures. There we learn that at moderately high temperatures (much below 10,000 deg. Fahr.) oxygen and hydrogen only very partially combine—from memory, I believe, not more than to the extent of half their weight—the remainder of the gases of course combine, as the centre of heat is left behind. Thus, although the quantity of heat evolved by their combustion is the same, being divided over a larger volume, its intensity is proportionately diminished. This being so, it would seem to follow that the temperature of the oxyhydrogen flame must be very considerably lower than that hitherto ascribed to it; and, therefore, the possibility of substituting it in this, or in some other manner equally economical, for the several purposes here specified, appears so much the greater.

TRACTIVE POWER OF LOCOMOTIVES.

From "The Railroad Gazette."

The power of any locomotive is limited by the *friction* or resistance to slipping or sliding between the tread of the driving-wheel and the rail. The word "adhesion" is sometimes used in this connection, but it can be applied with correctness only to a resistance like that which is offered to the shearing of a body, as a bar of iron, in which the particles of the metal are forced to move or slide upon themselves while the shearing is taking place. Hence the ability of an engine to move a load will depend upon *the weight resting upon its driving-wheels and the condition of the surface of the rail*, because the most careful special experiments and extended observation in practice show that, in common with metals so nearly similar in character as rails and tires, whether of iron or steel, the friction is almost exactly proportional to the perpendicular pressure between the surfaces, or, in the case of the locomotive, to the pressure upon the rail. It is by this friction that the wheel is prevented from revolving freely when pressure is brought upon the piston, and this friction is always greatest, and the engine can draw the heaviest loads, when the rail is either perfectly dry or perfectly wet, so that the surface of the tire may come into close contact with the surface of the rail without the intervention of any slippery film of moisture.

The general law, deduced from the most exact experiments, is that the force required to move one body when sliding upon another corresponds very nearly to the perpendicular pressure between them multiplied by the *co-efficient of friction.* This co-efficient is simply the relation or proportion which the pressure required to move a body upon any surface bears to the weight of the body itself, and for general purposes may be stated to be from 1.20 to 1.10 between metals when properly oiled. If the surfaces are not properly smoothed, or if the pressure between them is so great as to produce grinding or abrasion, then this law will not hold good, but the co-efficient will increase rapidly to a point determined by the special condition of the case. It is also evident that this co-efficient or proportion will diminish when the surface sustaining the weight of the rail, in the case of the locomotive, becomes more slippery than usual, as when snow or ice accumulates on the track, or sometimes during a slight rain, and hence, as is well known, the tractive force of any engine may be very greatly reduced at such a time.

Since, then, the power of a locomotive

depends so entirely, other things being equal, upon the weight carried upon its driving-wheels, it might seem necessary merely to increase the total weight of the engine by loading it with pig-iron in order to increase its tractive powers; but further consideration will show that this is not true. To illustrate the actual state of the case, suppose a locomotive to be firmly attached to a solid rock which cannot be moved. If steam be then admitted to the cylinders, a pressure will be brought upon the driving-wheels tending to make them revolve, and, in this supposed case, they can only slip upon the rail. This slipping will always take place when the pressure upon the piston, due to the steam within the cylinder, is greater than the product of the weight of the engine multiplied by the co-efficient of friction, since, as has already been shown, there is no other means than this of holding the wheels to the rail. Slipping will not occur in this case if the pressure upon the piston is less than the product of these two factors. If the weight of the engine be not great enough to prevent slipping for any given size of cylinder or pressure of steam, then an increase of weight may usefully be made, so that this product may be increased by which, as has been shown, the tractive power of the engine is measured or limited.

It will be seen, then, that with any given size of cylinder and standard pressure of steam a certain weight must be given to the locomotive, so that, under ordinary circumstances of weather, etc., no slipping of the wheels may occur, and also that no useful result can be obtained by increasing this weight beyond this certain amount; for the pressure upon the pistons cannot be increased beyond this assumed limit, and hence no additional load can be drawn, even though no slipping should take place.

The objection urged against the use of six-coupled engines, that they have a long rigid wheel-base, is an important one, and it is receiving serious attention in England, where these engines are vastly more common than in this country. Few builders, however, would put 3 pairs of driving wheels under any engine without making the boiler and other parts longer or heavier, so as to furnish a weight to be borne upon each pair of wheels equal, or nearly so, to that borne by each pair of wheels of an ordinary four-coupled engine, so that the larger engine may be efficient just in proportion to its size.

The grand objection to any increase of the weight of our engines, as now constructed, is that it is too destructive to the track to load each pair of wheels even as heavily as is ordinary now. The blows dealt by passing wheels upon the rail-joints, and the bending or breaking strain brought at any instant upon the joint in the rail where a wheel presses, depend upon the weight which the wheel carries, as well as the speed at which it moves; and hence to diminish our track repairs, that which is nearly or quite the most greedy of all maintenance accounts, the load borne per wheel in our locomotives must be lessened at least one-half, so that it may more nearly agree with the load borne per wheel in the cars. How this can be done without increasing the rigid wheel-base while the present boiler and cylinder capacity are retained, is one of the most trying problems of the present day among locomotive builders, and certainly the most promising commencement of its solution is the introduction of the Fairlie engine, notwithstanding the numerous complications with which it is still beset.

A project is on foot in St. Louis to build an immense structure, to embrace under one roof a grand union railroad depot, custom-house, merchants' exchange, hotel, railroad office, and other places of business buildings, to occupy three entire blocks, from Fifth street to Eighth, and from Washington avenue to Green street. This includes the site of the burned Lindell Hotel. From the bridge now building, trains would pass through the tunnel under Washington avenue to the passenger depot, which would be twenty-two feet below the surface of the ground; thence westward to a great union freight depot, to be erected on the ground formerly covered by Chouteau pond, and through which the Missouri Pacific Railroad runs. The building is expected to cost $3,000,000.

The Rensselaer and Saratoga Railroad Company are laying steel rails between Saratoga and Ballston Spa.

THE SEWAGE OF THE AIR.

From "The Engineer."

It is admitted universally that the great subject of the disposal of our town sewage is the all-important engineering and chemical topic of the day, but the parallel case which is embodied in the question, How are we to neutralize in the best possible manner for all parties concerned the evils resulting from the discharge into the atmosphere of the waste gases of our factories ?—though scarcely inferior to the former in importance, has not attracted so much attention. The reason for this indifference is, perhaps, to be found in the fact that, considered as a nuisance to inhabitants or individuals, the annoyance caused by the fumes from the various manufactories is easily remediable under the Sanitary Act, while its equally important action upon vegetation and the crops of the farmers is not brought so prominently before the public, partly because of the apathy of the farmers themselves, and partly because of the difficulty of obtaining any redress. In the former case the remedies are clear, and the law is easy to set in motion, but in the latter the law is not so clear, and there are fewer parties interested who have the courage to enter upon the lengthy proceedings which frequently end only in greater loss to their promoters. In the one case the nuisance being obvious, easily traceable, and affecting large masses of the population, the law simply imposes penalties until it is stopped ; but when the crops and fields only are injured the question resolves itself into a matter of damages, perhaps to be followed by an injunction, if the injury be severe and lasting, thus necessitating a long and costly suit at law. The question is not whether any damage has been done, but how much—for obviously it would be an impolitic act to cripple by legal enactments, the producing power of a manufactory which does a vast amount of good at the expense of a smaller amount of injury to the neighboring farms. But the manufacturer, who may be enjoying a handsome return from his works, ought to recoup the farmer the amount of loss he may have sustained through the ruin of his crops by the destructive vapors from the said manufacturer's premises. It is immaterial to the farmer whether he gets his money from the produce of his farm or as damages from his neighbor ; and a man who is enjoying a good income from his business surely cannot object to part with some of it to enable him to keep the rest in comfort. So far so good ; but now the difficulty arises, how is the amount of damage, and consequently the amount of compensation, to be ascertained ?

If there be only one factory which causes the evil the matter is simple. The farmer has only to show that the smoke from this factory falls on his land, and that his crops are injured to a given extent. When, however, there is an aggregation of such works, each, perhaps, giving off variable quantities of acid vapor, and situated at varying distances from the complainant's land, the latter's difficulties commence. If he fix upon an individual manufacturer and attempt to saddle him with the whole of the damage, he will probably be shown that he is not acting in perfect fairness to the defendant, who will point to his neighbors, and will show that he alone did not produce all the injury, and that he should not, therefore, be called upon to make good all that the farmer demands. In the face of all these difficulties, then, we cannot be surprised that so few efforts are made to wrest from the owners of factories compensation for the injuries they cause.

An attempt was made in 1863 to remedy this crying evil by the passing of the Alkali Act. It was admitted that the hydrochloric acid vapor which is disengaged in large quantities during the process of the manufacture of alkali from common salt, was the greatest cause of the destruction of vegetation, and this Act was therefore directed towards the evil. It then became law that every alkali manufacturer should condense at least 95 per cent. of the hydrochloric acid vapor, and inspectors were appointed who had full powers to enable them to ascertain whether the stipulations of the Act were properly complied with. If the inspector detected any infraction it was his duty to give prompt notice to the manufacturer, and if this did not prove sufficient he was empowered to institute proceedings, with the consent of the Board of Trade, in the County Court

of the district to which the offending factory belonged. This Act, which after all was more an experiment than a comprehensive legal measure, has been completely successful in its operation. As a matter of fact, manufacturers frequently condense more than 95 per cent. of the acid vapor, to their own enrichment, and the more effectually this condensation is performed the more perfectly and economically is the factory known to work. The public, however, cannot expect to rest satisfied with an enactment which can only apply to one out of the legion of processes which inflict equal injury, and it is here that we think it is imperative that some further steps should be taken. Let us see what provision is made on the Continent in similar cases.

In France legislation on these matters is founded on what may be called the preventive system. The law fixes a general principle, and leaves the execution of the means of carrying it out to the local authorities. Each prefect, aided by his *conseil d'hygiène*, gives permission to each of the factories of his department to work, and he binds them to observe certain regulations which he lays down to guide them in carrying on their processes without injury to the public good. The authorization prescribes the mode in which the nuisance of waste gases is to be prevented, and will not allow any deviation. To insure that these regulations shall be properly obeyed, a power of inspection is conferred on the local anthorities, which, in the majority of cases, is exercised by the police. What is the consequence? A few of the larger and better-conducted manufactories observe the rules, but the greater number of the small works ignore them altogether, and in many instances go to work without even the necessary authorization. Complaints, however, are rare, apparently because of the apathy frequently present among people who endure a nuisance in common, and also because of the reluctance of each one to be first to push for the redress of an abuse. Moreover, the rule which compels the use of a given method of prevention, dependent, as it is, upon the scientific knowledge or experience of the *conseil d'hygiène*, frequently ends in an inefficient means being adopted, and probably checks invention. The system of inspection has not been found to work well, and some of the departments have, we believe, appointed efficient inspectors, whose sole duty it is to attend to the various factories in their districts; but still there are no central Government inspectors. Popular feeling, too, has lately set against the strict regulations of the departmental officials, and the decree of 31st December, 1866, prepared under the advice of the *Comité Consultatif des Arts et Manufactures*, has removed much that was objectionable. One of the consequences of this improvement that has been noted is, that strenuous efforts have been made to discover the best method for the absorption of nitrous vapors, and the destruction of the sulphuretted hydrogen.

In Belgium the law has moved upon the same principle as in France, but the general tendency is to follow the English model. Here the inspectors have full powers. They are allowed to enter works at all hours, to assure themselves that the rules of the establishment are being complied with, and the proprietor is bound to produce, if required, the plans of his works, and the official documents which regulate his course of manufacture. Still, there is a feeling that all restrictive enactments should be swept away, and that Government interference should be confined merely to the prevention of public nuisance. Thus while manufacturers would be freed from rules confining them to certain processes of manufacture, the local authorities would be further strengthened by Government inspectors in their efforts to preserve the public health. It may not be out of place to give an instance here of the way in which the Belgian law fails to fulfil its purpose, and it is evident that similar cases might arise under the French law. Not long ago the Brussels Committee of Health declared, in relation to complaints respecting a certain factory in that city, that although the complaints were well founded the manufacturer had been careful to keep within his regulations, and so no help could be given. The Committee went still further, and even declared its inability to make any additional regulation to meet the case. In Prussia also the principle is the same as in France, but inspection is more active. It is confided, for all kinds of manufactories, to the communal authorities, who in their turn exercise it through their architect or engineer, generally a man specially ac-

quainted with the working of industrial establishments. This power of inspection is further strengthend by the addition of Government inspectors, who proceed to places where cases of importance may require se·tlement, and who also afford the benefit of higher knowledge and experience to their local brethren. This system has resulted in the prevention of any great abuse, but it would also seem to have suppressed that spirit of invention and research which is so remarkable in England.

These, then, are the various practices of other countries, and it is quite clear that we should not be gainers by their adoption in our own. The extension of the existing Alkali Act to comprehend other manufactures, and no more, would not suffice, because it would not do to include in the operation of an Act a process for the attendant nuisance of which there did not exist an adequate remedy. A good suggestion, however, has been thrown out by Mr. A. E. Fletcher, who is, we believe, an inspector under the Act for a portion of Lancashire. That gentleman suggests that in places where complaints are made by farmers against manufacturers, of damage done to their crops by corrosive smoke, the district should, upon the requisition of a certain number of inhabitants, be called a manufacturing district. To such a district an inspector should be appointed who should have power at any time to ascertain the nature and amount of the gases escaping from the var ous works. At the end of each month, or longer period, he should publish a list of all the works in his district, with a number indicating the average amount of acid vapor he had found on his separate visits. Here his duties would end. He should be neither prosecutor nor judge. He should simply publish the facts he ascertains, those facts which the farmer could never ascertain. It would thus become necessary to the manufacturer to adopt every means in his power to limit to the utmost the emission of noxious vapors, and he would probably find the introduction of even costly methods economical, provided it raised his place in the list, and so diminished for him the farmer's claim. This proposal is certainly practical, and coming, as it does, from one who has seen much of the actual working of the evil, is all the more valuable ; but the whole question requires careful consideration. There are so many conflicting interests and details to be observed and provided for, that it is necessary to advance very cautiously in working out a perfect system. Nevertheless, the suggestion deserves serious consideration. We shall probably return to the subject of atmospheric pollution before long.

ELECTROLYTIC INSULATION.

From "The Electric Telegraph and Railway Review."

We have to direct the attention of our telegraphic readers to a novelty in electrical science, and to a question which may, or may not, become of great practical importance in electro-telegraphy,—more especially in connection with under-ground lines. This novelty—for it is a new application of old facts—is what has been termed Electrolytic Insulation ; and the question is whether this mode of insulating a current, or, rather, of insulating from each other two conductors forming the "sending" and "return" paths of a current, can be utilized for telegraphic circuits. We will first describe what electrolytic insulation is ; and we will then state what we know of the results which have hitherto been obtained in its experimental application.

Supposing that we are called upon to insulate from each other two wires respectively attached to the terminal elements of a battery—say of four Daniell cells ; the plan which first suggests itself is simply to place these wires apart *in air*, or in other words to utilize this common dielectric for the purpose of insulation. If, however, the wire be several hundred yards in length, we have to use another dielectric—stoneware or porcelain, glass or ebonite, etc.—at the points of support. Or, we may completely encase one of the wires in a dielectric of another class, such as gutta-percha or india-rubber ; using

the uncovered wire, instead of the earth' for the return current.

All these are examples of *dielectric* insulation. But the wires may be insulated from each other, under any given electromotive force, "by means of good conductors of electricity (metals and electrolytes) so arranged as to generate an electromotive force which opposes the escape of the current when the latter is transmitted in a particular direction."* The insulator is then electrolytic. If, for instance, we respectively connect the wires above mentioned to the poles of another battery of four cells of Daniell, so that the electromotive forces of the two batteries may be opposed to each other, no current will pass; although a complete conductive circuit exists. Now this second battery—which is not required to transmit a current, but merely to exert statically a certain opposing tension or electromotive force—may be constructed in the form of an elongated cylinder, of any required length, composed of a tube, or series of concentric tubes, having as a central element the wire to be insulated. The tube, or tubes, and central element, being metallic, and being separated from contact with each other by means of a fibrous material containing an electrolyte, or moisture, constitute in fact a voltaic battery (if the opposing metallic surfaces be dissimilar), or a secondary battery (if the opposing surfaces be similar). The poles of this battery will be constituted respectively by its outer surface and the inner conductor; and the number of cells connected in series, and consequently the electromotive force of the arrangement, will be as the number of concentric tubes. It will be seen, therefore, that if the poles of a Daniell battery of equal electromotive force be respectively connected, through a galvanometer or other indicative instrument, with the poles of this elongated battery, at one of its extremities, no current will pass through the conductive circuit thus constituted *until the poles at the other extremity be brought into metallic contact.* When this occurs, there will be a complete *metallic* circuit, free from any opposing electromotive force for the current from the Daniell battery; and thus current, starting from one pole of the latter, will traverse the inner conductor of the cable-battery and the wire uniting its poles at the distant extremity, returning by the external tube, or *vice versâ.* Signals may thus be produced, at one extremity of the cable-battery, by uniting its poles at the other extremity.

Professor Miller, F.R.S., of King's College, thus describes an experimental or model cable on this principle, and some of the results obtained with it, which have not hitherto been published:—

"The cable was made in a series of lengths of a yard each. I was informed that each of these lengths consisted of a conducting core of galvanized iron wire 1 yd. 2 in. in length, coated with a fibrous material—this coated wire was enclosed in a soldered leaden tube 1 yard in length. The tube was then covered with thin zinc foil, and this in its turn was coated with fibrous material. The whole was then enclosed in a second leaden tube 1 yard long. Each layer of the fibrous material had been previously steeped in a strong solution of sulphate of magnesia, and allowed to become partially dry by exposure to the air.

"The composite tubes prepared as above described were laid side by side on an uninsulated wooden table covered with sheet lead (earth). The projecting ends of the galvanized iron core were connected alternately with the wire adjoining, by means of binding-screws and short pieces of copper wire, so as to make one continuous conducting cable, of 97 yds. in length; the three other lengths needed to make up the 100 having bean damaged.

"One extremity of this conducting wire was attached to a galvanometer and through this, by means of a commutating key, was permanently connected with the negative pole of a two-celled Daniell's battery, the positive pole of which was connected with the 'earth,' or with the outer surface of the cable through the leaden table.

"The other end of the cable was connected with a series of three resistance coils, consisting of 1,000 yds. of fine silk-covered copper wire, 32 gauge; and the other end of these resistance coils was insulated, but could be connected to earth at pleasure by means of a key.

"Every time that this connection of the earth with the galvanometer was made, the needle of the galvanometer was strong-

* Specification of Letters Patent to D. G. Fitz-Gerald, dated 18th February, 1869, No. 501.

ly deflected, and signals were transmitted through the resistance coils and cable.

"When thus arranged, the entire cable itself formed a battery of two cells, acting so as to produce a current in the *opposite direction* to that generated by the signalling battery, the electromotive force of which latter somewhat exceeded that of the current which the cable tended to produce, but which it did not actually furnish.

"That this really was the case was shown by reversing the direction of the current from the signalling battery, so as to cause it to *coincide* in direction with that from the cable. The galvanometer was immediately deflected with energy, and the needle thrown against the stop at 90°. The insulation effected by the cable was thus shown to be due to the electrolyte and not to any interposed dielectric."

It is not often that a fundamentally new system of constructing electric telegraph lines, "ingenious, and founded upon a principle the correctness of which cannot be doubted in the main"—as Prof. Miller states the present system to be—is brought to our notice. Whether or not this device of electrolytic insulation be susceptible of being adapted to the practical requirements of telegraphy, it merits attention, and should be studied by advanced telegraphists. Our opinion is, that if certain mechanical difficulties in the construction of an electrolytically insulated cable can be satisfactorily overcome, this system might certainly become available for underground lines. The competent opinions which have been given as to the durability of such a cable are very favorable; metallic corrosion being obviated by the application of the principle upon which Sir H. Davy protected the sheathing of ships, whilst the decay of the fibrous material would not appear to impair its electrolytic property, nor to lead necessarily to any metallic contact between the elements of the cable.

We have recently witnessed an experiment—which may readily be repeated upon a small scale—with a modification of the apparatus above described, in which the "thin zinc foil" was dispensed with. The cable, at first possessed of no insulating power, becomes converted into a secondary battery by the passage of a strong current through it laterally from the inner conductor to the outer tube, or *vice versâ*. We may suggest the following miniature reproduction of this experiment to those of our readers who have time and taste for investigation. A galvanized iron wire 20 in. in length may be covered uniformly with hemp or cotton fibre, which is to be moistened with a solution of sulphate of magnesia (Epsom salts). This coated wire is then to be inserted into a leaden tube, 18 in. in length, the internal diameter of which should be just sufficient to allow of the insertion. If the negative pole of a Daniell's battery of 4 or 6 cells in series be now connected through a galvanometer (or "quantity" indicator) with one end of the inner wire, and the positive pole be connected with any portion of the tube, a strong current will traverse the arrangement. It will be noticed, however, that this current rapidly becomes weaker, and, when its intensity has fallen to a sufficient extent, it will be found that the arrangement, which has now become "polarized" or converted into a secondary couple, will insulate the current from one—or perhaps nearly insulate that from two—cells of the primary battery. Signals through the miniature cable may now be obtained by momentarily bringing the free end of the inner wire into contact with the tube. If this tube be in turn covered with fibrous material, as in the case of the inner wire, and inserted into a larger tube of lead, the cable, when subjected afresh to the process of polarization, will have acquired a double insulating power. By connecting up a battery through a galvanometer at each end of the cable, an electrolytically insulated telegraphic circuit will be represented; through which signals may be transmitted from either terminal by uniting the poles of the battery at that terminal, which is best done with the aid of a key to which the poles are connected.

It need scarcely be pointed out that the *inner* tube or tubes of an electrolytically insulated cable may be of very slight thickness, and that the same observation applies also to the fibrous coatings. Doubtless there are many difficulties to be overcome before this mode of insulation can become practically available in telegraphy; but it is quite possible that, in the future history of this science-art, electrolytic insulation may be made to render good service.

FERRO-MANGANESE.

From "Engineering."

The supply of manganese for the steel-makers in this country has, during the present war, been a subject of considerable anxiety to every one interested in that important branch of metallurgy. We are dependent almost exclusively upon one small district in Rhenish Prussia for the supply of spiegeleisen, and this Prussian spiegeleisen is the only form in which metallic manganese is practically used by the steel-makers in this country. There is another kind of spiegeleisen accessible to us, but not actually in the market in this country, viz., the Franklinite spiegel from the United States, but its price does not in ordinary times make the importation of this material possible in competition with the Prussian spiegeleisen, and its qualities are therefore little known. Some trials which have been made with Franklinite iron in this country are said to have given unsatisfactory results, on account of a considerable percentage of zinc which was present in the material. It is known, however, that in America the Bessemer steel works actually employ Franklinite iron, and seem to be satisfied with the quality of the alloy. The probability, therefore, rests upon the assumption that the prime cost of American iron is too high to permit any regular trade in this class of pig iron to establish itself between this country and the United States. At the outbreak of the present war, and particularly during the time when an invasion of Rhenish Prussia was considered a probable result, the supply for spiegel to the steel-works in this country became very precarious, and the demand rising in consequence of the kind of panic which came over the limited circle of consumers of manganese alloys, the price of spiegel suddenly rose to nearly double its ordinary value. At the same time the moderate stock on hand in the different stores and steel-works in England threatened to run out and leave the steel-masters short of an indispensable raw material for the manufacture of steel. The comparatively insignificant trade in spiegeleisen, which hardly exceeds 10,000 tons per annum, or a value of £60,000, as a maximum in ordinary time, has by this state of affairs become capable, when interfered with by unforeseen events, of checking seriously the production of about 200,000 tons of steel, and of putting a trade averaging about three millions per annum into a most precarious position. There was a time when the Government of this country was expected to interfere, and actually did interfere, with the prices of sulphur in Sicily, and, from equally powerful reasons, it might have been looked to for protecting the spiegeleisen trade from the injuries of the Continental war. Fortunately for us, such ideas of Government interference with trade no longer exist, and the steel-masters must look to their own resources if they desire to avoid any similar calamity, to re-occur perhaps with more serious consequences than those which were actually experienced at the beginning of the present war. Every steel-master ought to be able to make his own alloys of manganese, and thereby become independent of the uncertainties of trade, both with regard to the price and the quality of his products. It is not only a sudden increase in the price of spiegeleisen which steel-makers are exposed to, but it is also the inequality with regard to the composition and properties of the alloy itself when it is drawn from the blast furnaces of a distant country. The contracts made with spiegeleisen masters very often specially stipulate that the spiegel is to be made in winter, it being considered that the atmospheric condition in the cold season is more favorable to high quality. Other contracts exact the guarantee of a certain percentage of manganese, which is far above the average product of the spiegeleisen furnaces, and which, if conscientiously kept, must necessarily bring down the standard of the remaining portions which find their way into the English market in a more or less indirect manner, but which, after all, are used up principally in this country. In advocating the manufacture of manganese alloys by the steel-masters themselves, we desire to draw attention to the fact that this is actually the practice adopted in some of the most eminent steel-works on the Continent, and has been successfully carried out by them for some time past. M. Indica, the well-known manager of the Terrenoire Steel Works,

in France, has worked Henderson's process for making ferro-manganese; and the works of F. Krupp, in Essen, the Bochum Works, and several other Prussian steel-makers although in the immediate vicinity of the spiegeleisen district, have all adopted different methods of producing rich manganese alloys for the purpose of exercising a better control over the "temper" or quality of their high-class steel. A similar movement is now being made by some of the leading Bessemer steel-makers in this country, who are adopting Mr. Henderson's process for the manufacture of ferro-manganese. Mr. Henderson's patents are the property of the Tharsis Sulphur and Copper Company (Limited), of Glasgow, and this Company grants licenses to steel-masters for the manufacture.

At the last meeting of the Iron and Steel Institute, in Merthyr Tydvil, a paper was read upon this important subject by Mr. F. Kohn, which states that the cost of manufacturing an alloy of 20 to 25 per cent. manganese is about £7 per ton, independent of royalties, and that the market value of this material is correctly estimated by comparing the value of a mixture of ferro-manganese and ordinary hematite iron with the price of spiegeleisen of equal percentage. We do not agree with Mr. Kohn in this mode of calculation. The value of ferro-manganese for the steel-maker not only depends upon the absolute quantity of manganese, but within certain limits also upon the relative proportion which is held by the alloy. There are many brands of pig-iron in this country which require a rich manganese alloy when used for the Bessemer process, and the quality of Bessemer steel in general would be considerably improved with regard to great ductility and uniformity, if richer alloys of manganese were more freely employed by the makers than is the case at present. There is also the question of waste in the Bessemer converter, which appears to us to be very closely connected with the relative proportions of manganese and carbon in the spiegel, and which deserves a very careful consideration. The spiegeleisen used in this country contains on an average 8 per cent. of manganese and 5 per cent. of carbon. For every pound of manganese $\frac{5}{8}$ths of a pound of carbon are necessarily added to the charge when the spiegel is used. The quantity of manganese required for removing the surplus oxygen from a charge of Bessemer metal may be estimated at about $\frac{1}{2}$ per cent. of the weight of pig-iron in the charge with careful and experienced management of the converter and spiegeleisen furnace. Taking the relative proportion of carbon introduced with this quantity of manganese, we have $\frac{5}{16}$ per cent. of carbon in the steel, and this is very nearly the highest percentage admissible for rails and similar materials. For the softer qualities of steel, such as the ingots for weldless tyres and for boiler plates, this quantity of carbon is too high. To arrive at the desired result when no richer manganese alloy is at hand than this 8 per cent. "spiegel," the only course adopted is to blow more oxygen into the charge, so that a part of the carbon shall be combined with it when the spiegel is added. This apparently harmless artifice is a cause of great loss in every Bessemer steel-works. It is not possible to blow a surplus of oxygen into a Bessemer charge without forming a great quantity of oxides and silicates, which immediately pass into the slag, and are not subsequently brought back into the metallic state when the carbon and manganese are added. The quantity of metal which is in this manner entirely lost has no definite proportion to the quantity of oxygen, which at the same time will be left in the metal, in a form available for combining with manganese and carbon, and this is an unavoidable source of error and uncertainty. Under all circumstances, the loss of metal caused by the necessity of overblowing the charges is very considerable. There are not many records of comparative trials in this respect, but from some of the tabulated results collected at the time when Henderson's ferro-manganese was used in considerable quantities in Sheffield, it appears that, as compared with ordinary spiegel, the employment of rich ferro-manganese saved 5 per cent. of the metal in the converter when soft steel was made, and in some cases the difference appears to be greater still. From all these reasons it appears that the value of rich manganese alloys for the steel-maker has not hitherto been sufficiently appreciated, and that the present war will have given the impulse to a change for the better in this respect.

THE UTILITY OF RAILWAYS FOR WAR PURPOSES.

From "The Railway News."

The importance of railways for strategical operations has never yet been so clearly demonstrated as in the war between Germany and France, and it certainly could not have been carried on without them to anything like the same extent or with equal rapidity of action. In modern wars the possession of a railway is of much greater consequence than that of a navigable river or a highway on land, and as on the continent, with the exception of Russia, they are all laid down on the same gauge (4 ft. $8\frac{1}{2}$ in.), they can be used alike by the locomotives and rolling stock of friend and foe. If we consider for a moment that there are at the present time more than a million of Germans under arms, of whom, after deducting the great losses in the battles already fought, at least 600,000 have advanced into the heart of France, some of whom are at this moment under the walls of Paris—if we consider further that it is not only in the enemy's country, where the inhabitants are naturally hostile, and by no means inclined to furnish food and supplies, but that it has till lately been occupied by large bodies of French soldiers, who have not failed to exhaust the resources of those districts—it becomes clear that provisions, forage, ammunition, and reinforcements—everything required, in short, for the success of the undertaking and the sustenance of the armies—must be sent up every day from the depots in the rear to wherever the front may be, and that the further they advance the greater the difficulty must become.

In the present instance the difficulty has been much augmented by political and geographical obstacles. Owing to the interposition of the neutral territories of Belgium and Luxemburg in the north, and Switzerland in the south, the only spot where the two belligerent frontiers touch is the Palatinate or Rhenish Bavaria; and therefore there is but one line of railway available—viz., that from Mannheim to Forbach and Metz, for the southern line through Strasburg has been rendered impassable by blowing up the railway bridge between that fortress and Kehl, on the German side of the Rhine. But this route has the disadvantage of passing under the guns of the great fortress of Metz—indeed, it goes through a part of the outworks of the fortification—and thus there is necessarily a break of continuity. The Prussians have, however, shown that their engineers are fully equal to the emergency of the occasion, for within a fortnight they have not only surveyed the country, but actually laid down a railway of twenty-five miles in length from the station of Remilly (to the south of Metz) to Pont-à-Mousson, including a temporary but safe railway bridge over the Moselle, by which not only is Metz altogether avoided, but a saving is effected of nearly twenty miles in distance. This wonderful exploit—for it is a feat unparalleled in the history of railway engineering—was achieved by the Prussian Royal Field Railway Corps, a separate organization, formed with admirable forethought in time of peace, and attached as a branch of the Royal Pioneer Battalion. The sleepers and rails were supplied partly by the Rhenish Railway Company and partly furnished from the stock on hand in the magazines of the Saarbruck State Railway; whilst fatigue parties of infantry soldiers and pioneers, assisted by a party of colliers from the coal mines at Saarbrucken were put in requisition for the earthwork of the cuttings and embankments.

"All stratagems are fair in war," but the Germans have discovered to their cost that some of those put in operation by the French cause them a deal of trouble and loss of valuable time. For instance, the French had on more than one occasion to retreat so suddenly, and, we may add, unexpectedly, that there was no time to destroy the railways, fill up the tunnels, or undermine the bridges. It was, however, found that in several places where they were obliged to retreat suddenly and abandon their railways, they had cunningly taken out the screws; but without removing the rails, which to a casual observer appeared to remain intact and be available for immediate traffic. Fortunately the discovery was made in time to prevent any accident, but the consequences might have been most disastrous, not

only as connected with loss of life, but by blocking up the road and causing delays when time was so precious. Orders have now been given to exercise the greatest vigilance and caution, and the Field Railway Corps now carefully examine every single rail of the permanent way, and report it perfectly safe for traffic, before any train is allowed to pass over the line. *Experientia docet.*

Two uninterrupted streams of traffic continue to flow on this line night and day in opposite directions—the one bringing fresh troops, ammunition, fodder, and provisions from all parts of Germany, and converging upon Manheim—and the other carrying back to Germany the wounded of both belligerents, thousands of prisoners, and the empty carriages and trucks, as well as the captured artillery, mitrailleuses, and other trophies of war.

The difficulties of working the traffic on a railway in an enemy's country are much enhanced by two elements that have to be taken into consideration. The drivers, engineers, pointsmen, station-masters, signal workers, and the other employes necessary for working the railway have had to be brought from Germany, and at first were of course utterly ignorant of the locality, the system of shunting and signalling, and the other minutiæ of detail in the working of the railway. They are all in the temporary employment of the Federal Government, and have been furnished most willingly by draughts from almost every railway in Germany; but having all worked under different systems, it required strong efforts and energetic and experienced managers to organize them into one body, and make them work well together. The other difficulty is that in most parts of the line there is but a single pair of rails laid down, and when one considers the enormous traffic that passes over them day and night, and the difficulty of arranging the departures of the two streams of trains so as to prevent collisions, it is really no wonder should there be delays, or even occasional accidents, though we must add that of the latter there have been hitherto none worth mentioning.

This war traffic, great as it is, has now been augmented to a still further extent by the order to bring up the heavy siege-guns and mortars required for the regular besieging of Strasburg and Metz, which are so strongly fortified that they can only be reduced methodically. This battering train, with its accompaniments of ammunition, shot, and shells, was sent from Magdeburg, Spandau, and other distant fortresses, and required the services of no less than a thousand special railway trains of thirty carriages each to forward them to their respective destinations.

And, finally, a further strain has now just been placed on the capabilities of the railway and the energies of the employes by having to convey the wounded and unwounded prisoners of MacMahon's army, consisting of nearly 100,000 men, to Germany, together with the captured 400 field guns, 70 mitrailleuses, 150 siege guns found in the fortress of Sedan, and all the Chassepots and other small arms of the prisoners, as well as many of the stores and other trophies of war taken from the enemy. These can only be sent by one line of railway as far as Mannheim; but on the other side of the Rhine this traffic is divided amongst the several lines according to the destination of the prisoners of war in the fortresses of Northern and Southern Germany. For this service six hundred trains are now required, and we are informed that they have worked and continue to work with an amount of punctuality and freedom from accident which would compare favorably with traffic carried on during a time of peace.

SINCE the announcement of the existence in York county, Pennsylvania, of a deposit of iron ore whence steel could be made directly, much interest has been felt in the operation of the Company organized to test this. W. W. Welkes, President of the Company, reports that the pig metal with the ore was put in the puddling furnaces. The latter being new, and not having the right kind of cinders, it was not expected that the results of the first heat would be satisfactory. But contrary to expectations, the ball, when put under the hammer, indicated that the operation was a success. The bloom was reheated and rolled into bar steel of a good quality.

THERE are now 12,000 windmills in constant use in Holland, for drainage.

THE MOBILITY OF FIELD ARTILLERY.

A correspondent of the "Army and Navy Gazette" (London) writes as follows on the subject of Field Artillery :

Few people will be found bold enough to deny that amongst the *desiderata* for field artillery mobility may be assigned a high place. To so great an extent has this been recognized by the highest authorities that Gustavus Adolphus organized a flying artillery of leather guns, which, though far inferior in range and accuracy to the other ordnance in use at the time, left nothing to be desired as to lightness and rapidity of movement. Marshal Marmont and the Great Napoleon most impressively assign to mobility the second place among the qualities necessary to the efficiency of artillery in the field; and in our own army the Horse Artillery have been of late supplied with a gun known to be far inferior in shooting to that used by the field batteries, but which possesses the advantage of less weight both of guns and ammunition. As to the advantages derived from the leather guns of Gustavus Adolphus, no one who studies the history of his victory at Leipzic can well deny that even loss of range and accuracy was more than compensated for by celerity of movement. Napoleon's favorite operation, that of suddenly and unexpectedly concentrating an overwhelming artillery fire on a given point of his enemy's line, was one demanding in the highest degree rapidity of movement, and the disadvantages of slowness are aptly illustrated by the fact that in executing this manœuvre at Wagram, 15 out of 60 French guns were disabled before they could unlimber ; the greater portion of this mass consisting of foot artillery (which we at present term field batteries), and being in consequence compelled to advance into action at a walk. Now, as most of your readers are doubtless aware, the field artillery of the British army is divided into two classes, known respectively as horse artillery and field batteries, the former of which is intended to act principally in concert with cavalry, the latter with infantry. To secure sufficient rapidity of movement to the first of these classes, the gunners are mounted on horses, with the exception of two, who sit on the gun limber ; and it may be fairly said that no nation in the world possesses a better organized and equipped arm than the horse artillery of the British army. Our field batteries are also in many respects most admirable ; but in their case an extraordinary anomaly exists. While they are carefully instructed in a system of regimental drill, which involves mounting the gunners and frequently moving at a trot, they are unable to carry out either of these very desirable objects when working with other troops as if on actual service. This peculiarity arises from the fact that only one non-commissioned officer per gun is mounted on horseback, and the rest of the gun detachment, with the exception of two who, as in the horse artillery, are carried on the gun limber, have no means of accompanying the gun, should it move out of a walk, unless by mounting on the ammunition wagons ; but this, which is the system laid down for regimental drills, is strictly forbidden on service, as the wagons are never, if possible, to be exposed to the enemy's fire. Thus the pace at which a field battery can actually move is determined by the speed which can be obtained from its gunners on foot without exhausting them, for every soldier knows the importance of the first few rounds being quickly and accurately delivered, a result entirely unattainable with men blown and exhausted after a run of perhaps half-a-mile, probably over rough and uneven ground. The obvious idea which first presents itself to the mind of a civilian is, "Turn all your field batteries into horse artillery, and they will then be available to act either with cavalry or infantry." Unfortunately, one word puts this excellent and simple remedy entirely out of the question—that word is, expense. A battery of horse artillery requires more horses than a field battery, and horses, especially just now, cost money. It remains, then, for us to devise some other means of carrying a sufficient number of men at a trot to enable us to work our guns efficiently. Let us see if this problem has not been already solved. The Bengal horse artillery used to mount gunners on the off horses of the gun teams, and both horse and field batteries of the same army carried two on seats fitted to

the top of the axletree boxes. The Norwegian, Swedish, and Danish armies are without horse artillery, but their field batteries carry men on the off horses when required to move rapidly. The Austrians mount some of their gunners on a species of saddle on the trail of the gun, and the Prussians carry men on the axletree seats. The French, indeed, do not provide any of these means of carrying their gunners, but they are far less chary than ourselves of exposing their ammunition wagons, which, of course, enables them to make use of them as vehicles for the men ; and most people, moreover, will allow that late events should render us cautious in adopting French principles, whether in the administration or the tactical instruction of our army. We see, then, that other nations have recognized the necessity of mobility in their field batteries, and have adopted various means of obtaining it. The committee which lately decided on the artillery equipment for India introduced, among other valuable improvements, axletree seats for two men per gun, but, although this equipment is likely *in time* to be supplied to batteries on home service, the elastic nature of the period so described is so well known that the question naturally arises, whether something of the sort cannot be added to our present gun carriages. To this the answer is, yes. Seats can be fitted to the present pattern of axletree boxes, which will be quite capable of carrying two men, and these with the mounted non-commissioned officer and two, or, if necessary, three, limber gunners, will afford a sufficient detachment which can always be carried wherever and at whatever pace the gun may be required to go. One artillery officer in particular has made experiments with a seat of his own contrivance, with the most satisfactory results. It appears to be not only perfectly safe, but an easier and pleasanter seat than the gun limber. In fact, many who have tried it declare that they would sooner ride either far or fast on it than on the latter. The question being thus solved, what prevents seats of this or some similar pattern being applied to all our field battery guns ? The bugbear, no doubt, which has always interfered with the mobilization of field batteries in our service is the fear of their "galloping" and "aping horse artillery," but it is time that such unworthy and puerile jealousies should cease or be ignored. The point to aim at is, not the empty swagger of galloping past at reviews, and impressing the minds of the fairer sex by an appearance of dash and rapidity, but to place our otherwise excellent field batteries on such a footing that they may be able to perform their duties in conjunction with the infantry as efficiently as our unrivalled horse artillery can assist the cavalry. Numerous instances may be mentioned where the mobility of field artillery has conduced largely to success, and, on the other hand, where the want of that quality has hampered and crippled the efforts of generals and armies ; and surely in the British service, above all others, smallness of numbers should, as far as possible, be compensated for by perfection of equipment and organization.

BELGIAN COAL.—The exports of coal from Belgium in the first six months of this year amounted to 1,843,414 tons, against 1,640,823 tons in the corresponding period of 1869, and 1,759,712 tons in the corresponding period of 1868. France took 1,772,138 tons of Belgian coal to June 30, this year, against 1,573,169 tons in the corresponding period of 1869. The commercial relations of Belgium with France are now, however, greatly disturbed by the war, and the Belgian coal trade has been drifting in consequence into a state of dulness and depression.

AUSTRALIAN TELEGRAPHY.—It is interesting to note, in connection with submarine cables about to be laid off the Australian coast, that it has been ascertained that the bed of the Gulf of Carpentaria is composed of mud in which a cable would bury itself, so that it would be protected from any adverse influences, climatic or otherwise. Submarine routes between Java and Australia are not considered to present any serious difficulties.

THE total value of the river commerce of the towns and cities on the Ohio is estimated at $715,000,000 per annum. In this vast sum Cincinnati figures for $169,-506,000.

WAR AND EDUCATION.

From "The Builder."

War topics naturally occupy public attention almost exclusively. Literature has taken a fiery tinge. The daily journals can find no room for subjects such as, at other times, would command large type. For a few days "the Row" was paralyzed ; and the weekly issue of new books came to a stand-still. In art, in industry, in speculation, every one is pausing for a moment, aghast at the great events which are taking place under our eyes, or waiting for the next telegram.

Without overstepping the prescribed limits of our own columns, or invading the provinces of the periodicals especially devoted to military science, or to military history, there is much which the present campaign forces upon our attention, which lies on ground familiar to our readers. Strategy, tactics, and descriptive literature, we altogether pass by. But the war has already taught, and must yet teach, lessons of the utmost importance, of a more general nature, as well as some of a nature especially germane to our columns. The architecture of war, or the relation of military science and practice to the works of the builder, has received ample and most important illustration. No less have the mechanics of war been exhibited under a new light ; and even of more importance, as deeper and wider in their scope, are those loud and eloquent lessons which speak of the connection existing between the educational state of a country and its military prowess and national defence. We have long seen that national wealth would shortly be admitted to be little more than a fraction of the educational state of a country. It now almost seems as if the same might be said of national existence.

With regard to the architectural lessons to be derived from the war, they are, as we write, loud and repeated, although it may well be said that the most signal of them all is as yet unpronounced. In a word, the idea is this. The importance of fortresses is greater than ever. The fortification of towns and cities is a cruel mistake—that is to say, their fortification by walls and ramparts. The fortress that is of vital importance in the stern chess-game of war is a military place pure and simple—a nest for soldiers, placed so as to command a defile, a river, pass, or railway ; casemated so as to give cover to its defenders ; built on the live rock, so as to set the art of the miner at defiance ; provided with water by wells and springs pierced within the very heart of the citadel, so as to be incapable of being cut off by the enemy ; walled according to the best methods known to military science, and armed with heavy guns, which, if they attain the at present largest size of 600 pounders, will have four times the calibre of the most powerful siege guns that is yet practicable to place in the trenches. A properly provisioned and munitioned fortress of this kind, containing a garrison proportional to the strategical importance of the spot, may be made virtually impregnable, except by famine. With our late improvements in the preparation of food, with the meat extract of the Liebig Company, the Swiss condensed milk, the new German sausages, the best biscuit, and the most carefully-stored grain and flour,—such a fortress might be easily provisioned for three years. Had Metz and Strasbourg been fortresses of this kind, and in this good order, it is more than problematical whether a cautious strategist would have ventured a march on Paris.

On the other hand, the cruel error of attempting to combine city and fortress is pregnantly illustrated in the case of the two great arsenals of Lorraine and of Alsace. Fortified, in his time, by Vauban, and since materially strengthened, furnished with that best of defences, a wet ditch, or series of ditches, in which the water can be raised or lowered by the defenders, these cities were intended to form great offensive centres for warlike operations. The idea that they would have to resist any formidable invasion, is one that no Frenchman would have allowed himself to entertain for a moment. But under actual circumstances, not only has the presence of the large civil population involved suffering of a magnitude which even enemies shrink from inflicting, but the absolute military influence of the presence of so many non-combatants has been in every way prejudicial to the defence. A large garrison is required,

greater labor is entailed on every soldier, the points of attack are more numerous and more wide apart, and the provision that might prove ample for the soldiers, shrinks rapidly before the consumption of the inhabitants. The speedy acquisition of Metz has not been a point of strategic importance—that of Strasbourg has; as the railway communication across the Rhine is impeded by its guns. Thus the terrible expedient of bombarding the town itself lay, according to the admitted laws of war, at the discretion of the general commanding the besiegers. It is true that the King of Prussia ordered a procedure which would lay in ashes a town of German origin and history to be suspended, as a striking contrast to the vindictive destruction of Kehl by General Uhrick, and to the malignant melodramatic shame of the shelling of Saarbruck. The point we wish to bring out is, that while the purely military fortress of Phalsburg has held out, to the honor of its garrison, and as an appreciable item in the defence of the country, the mixed character of Strasbourg has caused a great national disaster. Even if the citadel should hold out later than the city, the military loss will have been more, and the military defence weaker, than in the case of a simple fortress, while the fact of drawing fire on a city of 70,000 inhabitants (the main use of the walls of Strasbourg) involves at once a political evil amounting to positive disaster, and an amount of useless human suffering most painful to contemplate.

In fact, the breadth and precision of the line drawn between combatants and non-combatants is not only a redeeming feature of modern warfare of the utmost importance, but it is one on the preservation of which depends the answer to the question whether war, with its new and terrible means of destruction, shall or shall not imply total extermination. Any confusion of the line of demarcation between regular hostilities and murder can lead only to the great increase of the latter. In the confusion of character caused by walling in civilians and soldiers together, nothing is more probable than such a mingling of all occupants and defenders in one indistinguishable mass, as shall lead to total extermination on the success of the siege. And it must be borne in mind that it is a military axiom that the resistance of any place that is not relieved is only a question of time.

The lessons thus terribly taught us have this direct home application. We should make Pembroke our great arsenal, rather than either Portsmouth or Plymouth. At Pembroke the severing of the military and the civil element is and can be more distinctly effected than at any other place of naval importance in the United Kingdom. The few streets of workmen's houses that surround the dockyard might be swept away without any compunction. The immediate defence from the promontory crowning the head of the bay is good. The dockyard is situated at the head of a noble arm of the sea, or inland salt lake, the narrow entrance to which is capable of admirable defence. Within lies the Stack Rock, now fortified, which alone would sink any foeman within the gap. In the harbor the whole navy of England might ride in safety; and on sailing, a vessel is in the open sea in half an hour. In all our systems of defence these great peculiarities should be borne in mind. Very few spots in the world are so fit for a naval centre as Pembroke.

With regard to the mechanics of war, we do not wish to enter at this moment into the military questions of the relative value of the several arms. Our own attention has been long and not unprofitably turned to the subject; and our Snider rifle is a far more effective instrument than either the clumsy Chassepot, or the heavier, but somewhat better finished needle-gun. It is likely, however, that the latter weapons may better bear being knocked about, and certainly our own rifle requires to be used by a man more handy with his fingers than is needful in order to turn round the bolt-shaped handle of either of the other weapons. But the great mechanical feature of the war has been the service rendered by the railway system. The importance (to which we have just alluded) of any given fort, depends, now in very great measure, on the fact of its command of a railway line. Metz has been turned, in this respect, by the admirable expedient of constructing a temporary line of railway. The advance of the German host has been made at a rate hitherto without any precedent, by the service of the German railways. Distance, in strategy, is measured only by time, and distance has been reduced to a

degree which Von Moltke has precisely calculated, but of which we can only say that it must be less than the half of that reckoned in any former calculations. Other mechanical appliances have been pressed into the German service. Traction engines, the enormous power of which we are only beginning to realize in this country, are employed to move heavy guns into position. And captive balloons, although to our surprise they do not seem yet to have been employed, are in preparation. The admirable service of a secret underground telegraph is said to have been discovered, and cut, between Strasbourg and Metz. The field telegraph, for tactical purposes, has, no doubt, been organized as carefully as is now the case with that of our own Royal Engineers. Of the pontoon service we have heard but little, but it is, no doubt, efficient. The increased venom of the engines of death has not been such as to give great advantage to either side. But the command of the railway system has rendered possible an invasion in mass, which the preparation and the provision of border fortresses, properly proportioned, armed, and provisioned, must have, to say the least, materially delayed.

While we can thus already see, with no indistinct vision, some of the lessons which the statesman and the military architect and engineer cannot fail to draw from the terrible experience of our French neighbors, there is yet another which comes with more momentous force to ourselves. We have more than once insisted on the importance of bringing up our national education—in other matters than Latin and Greek—than reading, writing, and arithmetic—or even than the higher mathematics—to the level of more educating nations. We know from the reports of our own Education Commissioners, as well as from those of foreigners, that we occupy all but the lowest place in Europe in this respect. In the rapidly evaporating Roman States, indeed, and wherever the priest has his own way, thick and utter darkness is the object successfully attained by what is called education. Next to priest-ridden countries, come professor-ridden countries—or those in which competitive examination is adopted as a test of merit. This has been especially the case in Austria, which is called, *par excellence*, the *pays à l'examen*—an examination country. We are at present cheerfully and contentedly engaged in promoting ourselves from the first of these categories to the second. In France, while very much of the rural part of the country may still come under the sacerdotal extinguisher, there is a great amount of scientific, practical, and industrial education. But throughout the entire country the schoolmaster has been handicapped. A central impulse has been given which every lyceum or school has been compelled to obey. The first object of the entire and severe course of schooling prescribed to the French boy was to make him a good Imperialist. Hence the terrible inability to look fact in the face, or to serve or save the country, of which each day furnishes such disastrous truth.

Now, when we see this one-sided or no-sided education brought into contact with the broad and paternal culture of Germany, the results are even more striking in war than in peace. Of all the Germans round Metz, there was hardly a man who had not an idea of the plan of the campaign. He knew the object of that great silent strategist who had moved king and princes, and *corps d'armée*, like pawns on the board, though he might little understand each individual move. He intelligently received and faithfully obeyed orders. He regretted having to leave his home; but, meantime, his life was at the service of his country.

The French army, judging from their own reports as well as from those of English visitants, were in the very opposite position. Not a map of the seat of war was to be seen. Even the officers pent up in Metz thought that they were brought to the front to defend that city; the soldiers thought nothing, except that they were betrayed. They formed a class apart from the officers, though the latter rise from the ranks. They mistrusted them, and even fired upon them, and if we can believe but the half of the tales of plunder, conceited ignorance, and utter carelessness that we hear of marshals, generals, and even subalterns, driving luxuriously to war, as to a promenade, in the rear of their regiments, we can hardly wonder at it. Thus the educated and uneducated army, the armed nation, and the paid machine, came in collision. With what result?

Since the introduction of mercenary

troops into warfare first spread from the example of the ever-contending Italian States, the great question of the natural relation between the army and the nation, between the State and its armed means of defence, has not only been a study for the statesman, but a problem involving very shifting and inconsistent elements. Into that long and interesting history it is unnecessary here to enter. The last case of the problem has now received a solution so decisive that none who regard the matter from the scientific point of view can hesitate as to the import of the facts.

The two opposing forms in which military defence is organized (or is thought to be organized) by modern civilization have been brought face to face. The balance has never for an instant wavered. And although in the scale that has kicked the beam it is easy, after the event, to recognize certain elements of failure, that may be thought foreign to the question of principle, it may yet be seen that, for the introduction of these foreign and disastrous elements there has, practically, been found ample room in one system, and little or none in the other.

On the one hand, we have seen a professional army, reckoned, less than three months since, not only the finest in the world, but the finest that had ever been seen in the world. This army was permanent, mercenary,—raised, indeed, not by voluntary enlistment, but by conscription, yet possessing an *esprit de corps* that very rapidly transformed the conscript into the soldier. To the perfection and the brilliancy of this great military engine the resources of a nation of thirty-seven millions and a half of people were freely consecrated. It was the first object of the French Budget, the chief pride of every Frenchman. Not only was the army petted, not to say pampered, as the *elite* of the nation, but it was formed on the principle of giving disproportionate value to picked corps, as compared with the great arm of most great generals, the infantry. Such was the prestige of this army, such the amount devoted to its production and maintenance, to its terrible and secret artillery and to its brilliant guard, cuirassiers, and "dusk faces with white silken turbans wreathed,"—that we are told that an English Cabinet Minister declared his belief that it would be in Berlin within three weeks from the time that its leader threw down the gauntlet.

In opposition to this *chef d' œuvre* of the prætorian system was an army of altogether different organization. It was one formed on the old-fashioned principle that every man is the natural defender of his own hearth, and that, in case of need, he is bound to pay, not only in purse but in person, the cost of that defence. Having known what invasion was, and having drained the bitter cup to the very dregs, the Germans betook themselves to prepare a mode of prevention, with that same patient, steady, unflagging, undemonstrative, successful energy which a phlegmatic and resolute race have brought to bear on so many difficult problems of her vital interest. If the nation could but be prepared to rise in arms as one man, or rather as a succession of men, advancing decade after decade, the standing army that they would require would be only such as was needful to keep up the *cadres* of the organization, and to educate the lads who, year after year, arrived at the age of military discipline.

So admirably was this great system ordered, so ample were the preparations of the heavy and costly material of war, so prompt and effective the means of transit, that at the first great call, when the wolf was indeed coming, the mighty engine started without a check. Peasants and nobles, learned men, wealthy men, busy men, walked rapidly and quietly to their nearest depot. They came out armed and in uniform, in bodies that flowed, like contributing rivers, to the frontier.

The one grand advantage supposed to be possessed by the standing army was its instantaneous capacity for movement. The trumpet had but to be blown, and the troops were on the march. For the concentration of the citizen army, on the other hand, a certain delay was unavoidable. It entered into the calculations of the strategist. Each day, from the date of the order to arm, brought two army divisions to the standard. But it so turned out that the machine that was to be ready for instantaneous service was out of gear. The professional army did not work, and the citizen army did.

It does not follow that a standing army is necessarily a source of private plunder. But it is no less certain that the prætorian troops, which were thought the finest in

the world, have thus failed in the hour of need. It cannot be urged, henceforth, that the vast expense of a standing army gives a reliable safeguard to a great country. The evidence so far as it goes is the other way. And it is clear that a well-ordered citizen army can be raised, and armed, and sent to the point of danger with a celerity hitherto undreamed of.

We cannot but believe that the German system will, for the future, be the European system. That there will be many to deprecate its introduction into this country we do not doubt. It is a strong characteristic of the Englishman to resist improvement to the last hour, and then to effect it with more haste than good speed.

But apart from the domestic question, we trace in the grand German crusades an augury for the future education of the world. To take every lad, before either stature, or gait, or habit, is formed (often boorishly formed), and, as soon as he is able to endure a certain amount of hardship without checking his growth, to give him an education at once physical and moral,—to teach him to march, to ride, to fire, daily to pass many precious hours in the free open air, and even more than this, —to give him habits of order, of precision, of cleanliness, of truth ; to teach him how to obey, and thus how to command ; to tell him practically that he is a citizen, and that he has duties that he owes to his country ; and to redeem him, at this critical age, at once from idle frivolity and from the prematurely contracting pursuit of gain,—this will be a gain for the future generations of Europe not unworthy of the blood that has been shed to acquire the lesson. Nor is there any reason why the education of the soldier citizen of the future should be physical and martial alone. The State is responsible for bestowing the best cultivation on the youth whom she organizes as the seed-plots of her armies. The finest education given in this country is (or rather was before recent changes) that of the Royal Military Academy at Woolwich. Five terms of that wholesome discipline converted the pale and over-worked schoolboy (for all had to work in order to pass the barrier of Chelsea) into the vigorous, healthy, well-taught, reliable soldier. The battle of Sedan means that we shall not allow Switzerland and Germany to remain the only free countries that educate their youth for all the duties of grave and martial manhood. It means that every boy in Europe shall, sooner or later, be taught how best to become a man. The cad will, under the good influence of the drill-sergeant, attain some title to self-respect, in learning to respect his superiors. "Peace it bodes, and a quiet home, and successful rule, and due supremacy ;" and we may hope that peace will be more likely when war is no longer a trade, but is regarded as either the "worst of crimes or the most sacred of duties."

CENTRALIZING MOTIVE POWER.

By J. RICHARDS, M. E.

From "The Journal of the Franklin Institute."

The most important element in human industry is the employment of the forces of nature to produce effects beyond the scope of manual effort. To convert the crude materials of nature into such forms as will give us shelter, food, clothing, comfort, and pleasure, is the business of human life. If the reader will glance around him, no difference where he may be, I doubt whether he will be able to find a single article, great or small, of human production, that does not in some degree owe its origin to the employment of physical force ; and perhaps not one that is not, directly, or indirectly, the product of steam power. It forms an interesting problem. The paper on which we write, the pen, even the modern pen stem, the paper on the walls, every nail, the clothes we wear, the buttons, even the gas that furnishes the light, can be traced back to the steam-engine, or other motive power, that has been the main agent in its manipulation from the crude materials of nature.

It would be, further, a safe proposition to say that, next to human life itself, the great auxiliary of natural forces is to us the most important of earthly matters, so intimately are they connected with our

civilization and welfare. A thing, then, so important as motive power should command our continual and earnest consideration. Its economy and safety should be the most important of all questions in science. Whatever contributes, even in a minor degree, to its improvement should be recognized as of the highest importance, and take precedence over other discoveries and inventions in the rank of its great importance.

The improvement of the steam engine has, no doubt, of all other mechanical subjects, received the greatest amount of scientific attention, but it has, without doubt, been too much confined to various modifications in its mechanical construction with a view to special adaptation, and such economy as could be attained by improvements in steam generators, furnaces, and valve movements. The great question of *aggregated* or *segregated* sources for power has not (at least in this country) received much attention. The question of localizing and distributing motive power bears directly upon the two greatest questions involved: the cost of power and its safety. As affecting these conditions, it is proposed then, in a brief way, to present some views as to what might be gained by centralizing motive power in manufacturing districts and distributing it to be used by the manufacturers as we do gas or water. The first thing, aside from physical practicability, to be considered, is a proper medium for transmitting accumulated force in a way to be graduated, measured, and carried to a distance. This medium nature has provided in our atmospheric air, freed from a single fault, in fact impregnating our systems and essential to life. It is without money and without price. Governed by the laws of gases, it has all the properties and fulfils all the conditions of steam for a common engine, except that of lubrication. It is not explosive, it is free from danger; after use there is no residue, it can be discharged in any room, conducing to its comfort in either winter or summer. It is so subtile that it can be carried to any distance through innumerable angles without diminishing materially the original force; and we must consider it strange to see the attempts recently made, in Germany and elsewhere, to transmit power by means of ropes and pulleys, through long distances, instead of using compressed air for the purpose. In contrasting, or in considering different means of transmitting power to a distance, we find as the most important conditions: first, the loss by friction; second, durability; and third, first cost—we mean, of course, after demonstrating the practicability. Air has already been extensively employed for propelling machinery and in raising liquids, after being compressed by mechanical means. Its flow through pipes and the valves of engines and pumps has been demonstrated, and is, as we believe, determined by fixed formulæ. Machinery for compressing it, is well known as either the blowing engine or the hydraulic apparatus; so that perhaps the only things to be considered in suggesting a system of concentrating power at one point and distributing it to consumers, are the pipes for conducting it, and the saving that would be effected by such a system.

The difference in cost of generating 1,000 horse-power by a single condensing engine, favorably located, when contrasted with the cost of producing the same power with forty non-condensing engines with 25 horse-power each, is we will assume, as two to one, an assertion that is undoubtedly a safe one, when we consider the cost of attendance, room, wear, and fuel. Supposing that the cost of generating this power is in one case $50 per horse-power per annum, and in the other $100 per horse-power per annum, we have a saving representing the sum of $50,000 per year in 40 of our shops, supposing the amount of power used to average 25 H. P. each; or should we assume that twenty steam engines of 50 H. P. each, would cost proportionately compared with the large one of 100 H. P., we should have this saving represented in twenty manufacturing establishments using that amount of power.

This sum would lay conducting pipes through almost any of our manufacturing districts, to the extent of 1,000 H. P., and we would in a single year pay for the piping, and in another year pay for the compressing machinery, while either would last for twenty years.

The saving in cost, although no doubt the question that would have most to do with the inaguration of a system of centralizing and distributing power, is but one out of many involved. With a "pneumatic main" laid through the streets of our manufacturing districts, and each

manufacturer taking off his power through a meter, we would gain not only in economy and convenience over local steam power, but obviate nearly all that is objectionable in it. The danger from boiler explosions would be gone. The smoke from steam furnaces would be avoided, the heat and danger from fire would be avoided. The room would be saved, the water rate would be saved. The engine would not freeze in the winter. The cost would be as the amount of power used, which could be varied with the state of business ; or a change in the capacity of the motive power could be made at a trifling cost.

May we not look for the next great innovation in motive power to consist in centralizing it and distributing it by means of pneumatic apparatus?

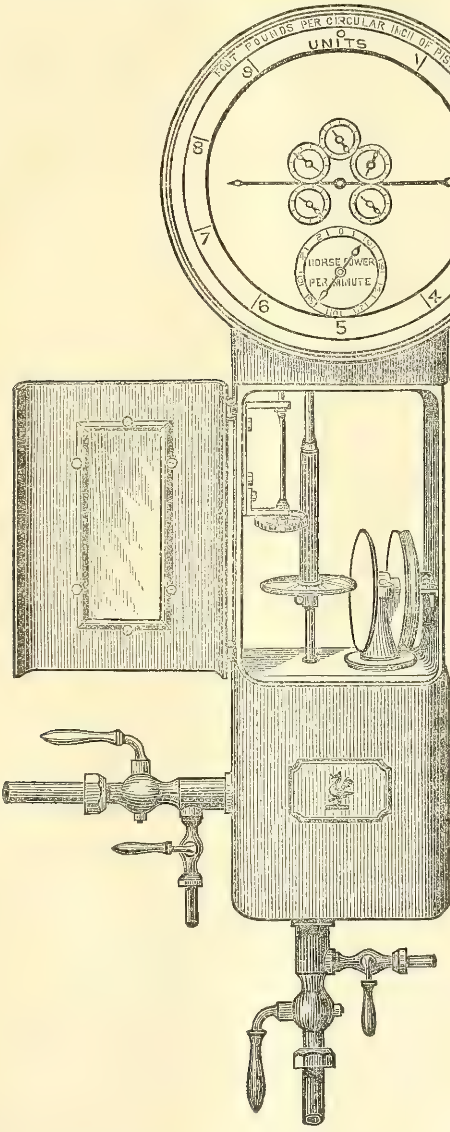
ON A STEAM POWER METER.

By Mr. ASHTON.

From "The Engineer."

The extent to which the employment of steam power in our varied industries, and as furnishing means of locomotion, has become a necessity, and the desirability of attaining the utmost economy in the consumption of fuel, render it a matter of the first importance to be able readily to ascertain the exact amount of power developed by steam machinery in a given time. Hitherto approximate estimates founded upon the results of isolated tests and experiments, or calculations based upon the diagrams produced by ordinary indicators, have furnished the sole means for the ascertainment of the duty of, or, in other words, the power developed by steam engines in all cases where the said power has been subject to variations. These indications have been taken at intervals of at least one day, and in most cases of a much longer period, and have simply been registrations of the amount of power developed during the one stroke, or the two or three strokes performed by the engine during the time of indication, the great variations in the load upon or the speed of the engine, and in the pressure of the steam occurring in the intervals between the indications being practically disregarded ; and even when a correct diagram has been obtained, the power developed during the indication has and can only be ascertained with any degree of exactness by a tedious process of measurement and calculation. The patent power meter and continuous indicator, on the contrary, not only measures the power developed during a single stroke of the engine with as great a degree of exactness as the best indicator hitherto in use, but also registers the result of the said measurement with as great a degree of exactness as it is measured, thus avoiding the errors arising in the operation of measuring and calculating the area of the ordinary diagram ; and, what is of more consequence, this measurement and registration are effected with reference to each and every stroke of the engine, and furnish a means whereby a correct judgment may be formed as to whether there has at any time been a want of due observance of economy in the use of fuel, or whereby the comparative merits of different kinds of fuel or of lubricants may be tested. In cases where power is supplied to tenants this instrument furnishes the only means whereby the power so supplied may be accurately measured. And in the case of marine engines in a rough sea it is the only instrument that can give any reliable information as to the power exerted by the steam engines, inasmuch as it is frequently impossible to obtain constant diagrams by the ordinary indicator during a whole voyage across the Atlantic. The steam power meter and continuous indicator, as its name implies, shows at all times the measure of the power developed by the steam engine to which it is applied, and registers the aggregate of that power during any required period of time. The instrument consists of a small double-acting indicator cylinder, $1\frac{1}{2}$ in. in diameter, each end of which is connected by means of a pipe with the corresponding end of the steam engine cylinder. These connections are made as short and direct as possible. The piston-rod of the indicator carries a long-toothed pinion, which revolves loosely on the rod, but is held endwise between two screw collars. This

gears into a toothed wheel, which is connected with and drives the indices. At the lower end of the long pinion, and fixed to it, is a light wheel, called the integrating wheel, having a smooth rim with a rounded face. To the upper end of the piston-rod is attached a spiral spring, which offers a resistance to the free movement of the piston in its course from the middle to either end of the indicator cylinder; on a short horizontal shaft is mounted a circular disc, whose face is



constantly, but not forcibly, pressed against the rim of the integrating wheel; this is effected by means of a light flat spring, bearing against the end of the shaft on which the disc wheel is mounted. A small cog wheel is also keyed on the disc shaft, and is connected by a rack or any other suitable means to the cross-head or other convenient reciprocating part of the steam engine. Or a small pulley may be keyed on the disc shaft, round which is wound a cord, whose two ends are at-

tached to the cross-head or other convenient reciprocating part of the steam engine, being carried thence round loose pulleys above and below. By either of these means the reciprocating motion of the steam engine is converted into a rotary motion of the disc, acting in alternately opposite directions. When there is no pressure on the piston of the steam engine, and accordingly none on the piston of the indicator, the integrating wheel is so adjusted that the point of contact of its rim with the disc shall be at the centre of the disc, that being the zero point of the instrument. When the pressure of the steam is admitted so as to act on the piston of the indicator the integrating wheel traverses in consequence from the centre towards the circumference of the disc, the distance traversed being proportionate to the pressure of the steam on the piston. Suppose, now, the crosshead of the steam engine, and with it the disc of the instrument, be moving, such motion will be communicated by the disc to the integrating wheel, and through it to the indices. The motion so given to the indices during this stroke of the steam engine is proportionate to the pressure of the steam on the indicator piston during that stroke. Let it now be supposed that the stroke is finished and a return movement is commenced, the disc will now rotate in the opposite direction, and if the steam acting upon the piston were pressing in the same direction as before, the integrating wheei and indices would necessarily go backward. If, however, the steam, as is usual, acts on the opposite side of the piston when the piston's motion is reversed, the integrating wheel will be moved to the opposite side of the centre of the disc, so that the integrating wheel and indices will be moved in the same direction as before, and the quantity of motion through the receding stroke of the engine will again be proportionate to the pressure of the steam on the piston during that return stroke. Here, therefore, is provided a means of moving the indices during each stroke of the engine through a space proportionate to the sum of the moments of pressure exerted during that stroke, or, in other words, a means of indicating the amount of power developed during that stroke. The relative proportions adopted for the several working parts in the present instrument are such that each division on the dial represents 1,000 ft. lbs. of duty for each circular in. of the piston of the steam engine. These proportions may be varied. Thus the parts of the indicator may be so arranged that the readings on the dial shall represent the number of horses' power given out during any required period of time. By closing the tap connecting one end of the indicator cylinder with the corresponding end of the steam engine cylinder, and opening the small drip tap to admit air freely to the disconnected end of the indicator cylinder, the indicator is thus rendered single-acting, and will show the manner of working and the amount of work done by one end of the steam engine cylinder alone. By opening the closed taps and closing the open ones the indicator is reversed, and the manner of working and the amount of work done by the other end of the steam engine cylinder ascertained. In the case of a non-condensing engine the integrating wheel would not return to the centre of the rotating disc during the back or return stroke of the engine by a distance proportionate to the back pressure opposing the motion of the steam engine piston, the effect being that during the return stroke the integrating wheel and indices would be wound back by an amount of motion proportionate to the loss of power by back pressure. Also, if the valves of the engine are opened or closed too early or too late, the integrating wheel will be seen to move backward at the beginning or end of each stroke, thereby showing work undone by an amount of motion proportionate to the loss of power by such "cushioning," or too late admission of the steam or too late exhausting of it. The instrument can be so constructed that paper diagrams may be taken indicating the action of the steam in each end of the steam engine cylinder, or in both ends conjointly.

Formula for showing the relative connection of the dimensions of the various parts of the power meter.

Let w = the weight in pounds required to distend or compress the spring 1 in.
" d = diameter of indicator cylinder in ins.
" D = diameter of integrating wheel in ins.
" L = number of teeth in the long pinion.
" M = number of teeth in wheel geared in long pinion.
" N = number of teeth in worm-wheel or first index-wheel.
" x = diameter of driving pulley on disc shaft.

Then d^2 = the area of the cylinder in circular inches, and $\frac{w}{d^2}$ = the pressure in lbs. of steam per circular inch on the piston to distend or compress the spring 1 in. One revolution of the disc with the integrating wheel 1 in. from its centre will drive the integrating wheel $\frac{2}{D}$ revolutions. Then $\frac{2}{D}$ of $\frac{l}{m}$ of $\frac{1}{n}$ = the parts of one revolution of the index for one revolution of the disc, that is $= \frac{2\,l}{D\,m\,n}$. And because $\frac{w}{d^2} \times \frac{3.1416\,x}{12}$ = the foot-pounds represented by one revolution of the disc per one circular inch of piston $= \frac{3.1416\,w\,x}{12\,d^2}$. Therefore, $\frac{3{\cdot}1416\,w\,x}{12\,d^2} \times \frac{D\,m\,n}{2\,l} = \frac{3.1416\,D\,m\,n\,w\,x}{24\,l\,d^2}$ = foot-pounds per one revolution of index, or assume one revolution of index = 10,000. Then $\frac{3.1416\,D\,M\,n\,w\,x}{24\,l\,d^2} = 10{,}000$, and $x = \frac{240.000\,l\,d^2}{3.146\,D\,m\,n\,W} = \frac{76394.194\,l\,d^2}{D\,m\,n\,W}$. Therefore each unit on the dial of the power meter represents 1000 foot-pounds per circular inch.

To find the work done by an engine in any given time.

Where d = the diameter of the engine cylinder in inches, n = the number of the meter index at commencement of time n_1 = ditto ditto ditto at the end of that time. Therefore, $1000\,(n_1 - n)\,d^2$ = foot-pounds.

To find the work done in horse power.

Where m = number of minutes elapsed between the times of reading the meter and 33,000 feet pounds represents the duty of one horse per minute. Then $\frac{1000\,(n_1 - n)\,d^2}{33{,}000\,m} = \frac{d^2\,(n_1 - n)}{33\,m}$ = load in horse-power.

To find the quantity of coal consumed per horse per hour.

Let H = horse effect of the engine.
" h = hours during consumption of the coal.
" w = the weight of the coal in lbs.

And $\frac{w}{h}$ = the number of lbs. of coal consumed per hour.

Also

$$\frac{1000\,(n_1 - n)\,d^2}{33{,}000 \times 60\,h} = H = \frac{(n_1 - n)\,d^2}{1980\,h}.$$

And because $\frac{w}{h} \over H$ = lbs. of coal consumed per horse per hour, therefore, $\frac{w}{h} \times \frac{1}{H} = \frac{w}{h}\,\frac{1980\,h}{(n_1 - n)\,d^2}$ or to $\frac{1980\,w}{(n_1 - n)\,d_2}$ = consumption of coal per horse per hour.

RANSOME STONE.

From "Engineering."

In front of the Temple Station of the Metropolitan District Railway two large areas extend on either side of the entrance to the booking-office, which are inclosed within a low brick wall, and a portion of this space is occupied by the only short open spaces above the railway, which were permissible upon this part of the Victoria Embankment. A handsome balustrade surmounts the dwarf wall, and gives a fine effect to the otherwise exceptionally good appearance of the station. We notice that Mr. Frederick Ransome has been intrusted with the construction of this balustrade, for which his artificial stone has been employed, and we believe that it is one of the most, if not the most, successful applications of his process. The plinth, pedestals, piers, and cornices of the balustrade have a uniformity of texture and color, that promise well for their durability, and give them an appearance of wrought stone ; indeed, the absence of tool-marks is almost the only indication of their material. The plinths and cornices are cast in convenient lengths, cored, and with slight recesses at the ends, the surfaces of which were roughed up while the material was plastic, in order to give the cement at the joints a better hold ; the piers are made in four pieces, the front with deep sharp cut mouldings, the back and the sides with half pillars cast on them. The pillars of the balustrade are made in three pieces, the base and cap being made with pins, which fit into corresponding holes

in the shaft of the pillars. In the curved portion of this balustrade the cornices only were cast in special moulds, the plinths and slabs forming the piers having had slots cut at the back, after which they were laid upon a curved template while in a plastic state, and so brought to the desired form. We believe that some alterations are to be made in the elevation of the Temple Station, and that the parapet that runs along the roof, and behind which is the Norfolk-street approach to the Victoria Embankment, is to be removed, and replaced by a balustrade of the same character and material as the one now being erected on the lower level.

We alluded some time since, and on more than one occasion, to the successful arrest of decay in stone by the application of the preserving material produced by Mr. Ransome, and we find that the process is being largely and profitably employed in Bombay. The Porebunder stone used for building purposes in that city and the locality, is of a very perishable nature, and a number of public buildings in which it had been employed have been showing signs of rapid deterioration. This decay has, however, been arrested by induration, and, as a natural consequence, the demand for the Ransome solution is considerably increasing in Bombay. Attention is also being carefullydirected towards the manufacture of artificial stone. It is now two years since Government works for its manufacture were started, but prejudice has steadily set its face against the material hitherto, so that it has not yet received a fair trial. The lack of endurance, however, in the natural building stone, and the necessity of procuring some more lasting material, has induced the Government to renew their efforts in making stone, and it is now intended to increase the existing works. Both branches of Mr. Ransome's process appear therefore to have a fair chance of extensive adoption in this part of India.

ON THE APPLICATION OF THE CENTRE RAIL SYSTEM TO A RAILWAY IN BRAZIL, AND TO OTHER MOUNTAIN LINES; ALSO ON THE ADVANTAGES OF NARROW GAUGE RAILWAYS.

By MR. J. B. FELL, C.E.

From "The Artizan."

Since the opening of the Mont Cenis Railway in June, 1868, other mountain lines on the centre rail system have been under consideration in different parts of the world. One of these lines now being constructed is in Brazil. It commences at the terminus of the Canta Gallo Railway, crosses the Serra at an elevation of 3,000 ft. above the Canta Gallo Line, and terminates at the town of Novo Friburgo, a distance of 20 miles. In some of its principal features this resembles the summit line of the Mont Cenis, the gradients for the passage of the Serra over a distance of 10 miles, being principally from 1 in 20 to 1 in 12, and the curve by which the line winds round the spurs or counterforts of the mountain being, for a considerable portion of it, from 40 to 100 metres radius. The narrow gauge of 1.10 metres has also been adopted. In other features, however, there is an important difference between these two centre-rail lines. The concession for the Mont Cenis was but temporary, terminating at the completion of the great tunnel, and the railway is laid on the existing public road, whereas the Canta Gallo Line will be permanent, and the works will be so constructed as to be especially adapted to its requirements. It will not have to contend with the difficulties of an Alpine climate, and, profiting by the experience of two years' working on the Mont Cenis, it will have the advantage of important improvements which have been made in the engines, carriages, and permanent way during that period. Consequently, the Canta Gallo and other similar lines, now being or about to be commenced, have the interest of marking a development of the capabilities and advantages of the centre rail system, as applied to the construction and working of mountain railways. It may be useful here to record what has already been accomplished in the task of carrying railways over mountain passes, hitherto inaccessible to the locomotive,

and of giving it the power of safely carrying trains of passengers and goods upon gradients and curves which would previously have been considered most perilous, and, indeed, impracticable. The Mont Cenis Railway has now been open for traffic 2 years and 3 months, and during that period the trains have run a distance of more than 200,000 miles, have carried between France and Italy over 100,000 passengers without injury to any one of them, and has effected the transport of a considerable quantity of merchandise. Since the month of September last, it has carried the accelerated Indian mail, and by the service thus established the delivery of the Indian mail in London *via* Marseilles has been anticipated by the Brindisi and Mont Cenis route by about 30 hours. The ordinary mails between France and Italy have been carried by the Mont Cenis Railway since its opening, and one night of travelling has been cut off the journey between Paris and Turin. Although the Mont Cenis Railway cannot be taken as a type of the best or most approved application of the centre rail system, it has had the effect of proving its mechanical practicability and safety when put to the most crucial test to which any new principle could be submitted. There have been mechanical defects in the construction of the engines which have added unnecessarily to the cost of traction, and these defects can and will be removed in the engines about to be built for the Brazilian and for future centre rail lines. The cost of traction, as might be expected under the circumstances, has hitherto been high—about 3f. per train kilometre ; but there can be no doubt that with improved engines and good management the cost of traction may be reduced to 1f. 50c. per train kilometre. The Semmering incline in Austria furnishes an example of the economy that may be effected by improved machinery and management, the cost of locomotive power having been reduced from 2.85 francs in 1860 to 2.15 francs in 1863, 1.70 franc in 1865, and 1.49 franc in 1866. In the four new engines last built for the Mont Cenis Line a considerable saving has been made in the cost of repairs by using four cylinders in place of two. By this arrangement the inside and outside mechanisms are disconnected, and any contention between the two is avoided. The adhesion, however, is equal to the two cylinder engines, and the power is transmitted from the inside cylinders to the vertical axles by means of a train of toothed wheels. In the new engines for the Canta Gallo Line it is proposed to dispense with the toothed wheels and substitute for them a system of direct driving by connecting rods. The power of adhesion will also be considerably increased. These new engines will have the advantage of being able to run at a speed of from 20 to 30 miles an hour upon the ordinary gradients of the line, and of taking their loads up the mountain section at a diminished speed of from 8 to 10 miles an hour. In an economic point of view the result of the application of the centre rail system to the Canta Gallo Railway will be as follows : The cost of construction, assuming it to be as estimated, about £300,000, would be at least doubled if made on gradients upon which ordinary engines could work. In this case the costs of traction and maintenance for a centre rail line will not be greater than for a line with ordinary gradients passing over the same country. The clear saving, therefore, effected by employing the centre rail system is at least £300,000, and the construction of a valuable line of railway has been rendered possible which would otherwise have been commercially and financially impracticable. A somewhat similar line of railway is under consideration by the Indian Government, from the port of Karwar to Hooblee, in the Southern Mahratta country, both by way of the Arbyle and the Kyga Ghats. The distance is 90 miles, and it is proposed to employ the centre rail for a length of about 10 miles upon gradients of 1 in 20 for the passage of the Ghat, by which a saving would be effected of about £500,000. The cost at the present time of the transport of cotton and other produce over the 90 miles is stated to be £235,000 per annum, and there is in addition the disadvantge of not being able to convey the whole crop to the port of shipment before the rainy season sets in ; a large portion of it has consequently to be housed and kept until that is over. Negotiations are going on with the Government local authorities and people interested for the construction of centre rail lines in Italy from the Adriatic to Maserata and crossing the Appenines to Foligno from Florence to Faenza, and for

three branch railways in the Neapolitan States; in France, from Chambery to St. André du Gaz and Lyons direct, crossing the Col de l'Epine; in Switzerland, for the passage of the Simplon; and in Spain, for lines from Leon to Corunna and Gion. The concession for the Mont Cenis Railway expires on the opening of the tunnel line, and when that period arrives it has been proposed to remove it to one of the neighboring mountain passes where it would have a permanent life. At the time the concessions were granted it was considered that the line would be worked for ten, or at least seven, years; the progress of the great tunnel has, however, been so much accelerated that it is stated the tunnel line may possibly be opened for traffic by the end of 1871. In that case, and taking into account the difficulties of all kinds with which the enterprise has had to contend, the Mont Cenis Railway can only be regarded as an experimental line, and the pioneer of a system destined to confer the benefits of a cheap and safe communication between many countries separated by mountain ranges hitherto impassable by railways and locomotive engines, and the promoters must look to the future for the reward of their labors and the anxieties of the past. Drawings were exhibited of a new system of narrow gauge or suspension railways, an example of which has recently been constructed as a branch line for carrying iron ore from the Park-house mines to the Furness Railway in North Lancashire. The gauge of this line is eight inches, and the length about one mile. It is carried at various elevations from three to 20 feet over an undulating country, passing over the fences, roads, and watercourses without requiring the construction of earthworks or masonry. The structure consists of a double beam of wood, supported at intervals on a single row of pillars. The narrow gauge is practically made equivalent to a broader one by the steadying power of guide rails fixed on the sides of the beam and below the carrying rails. The bodies of the wagons are suspended from the axles, and by this means the centre of gravity is brought low. They are also furnished with horizontal wheels which run upon the guide bars, and thus maintain the equilibrium of the carriages, and render it almost impossible for them to leave the rails. The Park-house line have a traffic of 50,000 tons per annum. The cost has been £1,000 per mile without stations or rolling stock. It was worked by a stationary engine and endless wire rope. The saving effected in the cost of transport will be at least 6d. per ton upon the distance of one mile. In Switzerland application has been made to the Government of the Canton Vaud for a passenger line on this principle, from the town of Lausanne to the lake of Geneva. Plans have also been laid before the War Office for accelerating military transport in foreign countries, and before the Governor-General of India for the construction of cheap branches from the trunk lines in that country. The gauge of these railways may be from 6 to 18 inches. They may be made of wood or iron, or of the two combined, and may be worked by either stationary engines or by locomotives of a form specially designed for the purpose. They have the advantages of being economical in both construction and working, they occupy but little land, and cause no severance, they may be erected with great rapidity, and being portable may be removed when no longer required and re-erected in another locality. Before the war commenced, an offer was made to the French Government to construct one of these portable railways to supply their army with from 1,000 to 3,000 tons of ammunition and provisions per day. The work would have been undertaken by a gentleman in Paris, who, with a force of 2,500 men, would have constructed from four to five miles of railway per day, following the advance of the army into Germany. The result has, however, shown how little such a provision was needed.

PORT DARWIN AND PORT AUGUSTA TELEGRAPH.—The South Australian Government have now a formidable enterprise on hand, nothing short of the establishment of a telegraph line from Port Darwin to Port Augusta. The cost of establishing this line, which will run quite across the Australian continent, is officially estimated at £130,000.

WELCH's patent preservative and anti-fouling cements for the bottoms of iron ships, after lengthened and severe trial by the Admiralty, are pronounced successful.

THE HISTORY OF MILITARY FIRE-ARMS.

From "The Mechanics' Magazine."

That gunpowder was used by the Chinese early in the seventh century is among the things not generally known. It was in the form of Greek fire, and was mainly used by the Celestials for the blasting of rocks. In the year 668 it was first employed in warfare, though in what way there is no record to show. Judging from other evidences of scientific progress in China at that early period, it is not improbable that some rude kind of fire-arm was devised and kept secret among the dwellers within the Great Wall, through the centuries that intervened before the use of gunpowder in Europe. We do not read of cannon being used before the year 1327, when Edward III. employed them in his first campaign against the Scots. The French also used cannon in the battle of Cressy, about twenty years later. At that time they were formed of an iron tube, strengthened by large rings of the same material, which being driven on while red hot formed by contraction a gun of great strength and firmness. In the reign of Henry V. bolts and "quarrels" were shot from cannon. These were succeeded by stones, and stones in turn gave way to iron bullets.

In the meantime hand guns had been invented. They were introduced into England by Henry IV., when he landed at Ravenspur, in 1471. The invention of hand guns is ascribed to the Germans, and probably dates half a century prior to their use in this country. A Birmingham gunmaker informs us that at first the hand gun was a simple barrel with an uncovered touch-hole at the top, mounted upon a straight stock, and was fired from a rest by means of a match. A few years afterwards the stock was bent, and the match-lock introduced. The accidents arising from these primitive guns were, as may be supposed, very numerous. The wheel-lock, an Italian invention, which lessened the danger of firing, was introduced in the reign of Henry VIII., and continued to be generally used for a century and a half. Fire-arms, however, were not at that period greatly relied upon for the purposes of war. The awkwardness of the guns, together with the great difficulty and expense of procuring gunpowder, led to a prevailing preference for old appliances, and so late as Elizabeth's time archers were the great strength of the English army.

Sir James Turner states that the pistol was invented at Pistoja, in Tuscany, by Camillo Vitelli in the sixteenth century, and another great authority, M. de la None, remarks :—"The Reiters first brought pistols into general use, which are very dangerous when properly managed." These Reiters, or more properly Ritters, were the German cavalry, who gave such ascendancy to the pistol as to occasion in France, and subsequently in England, the discontinuance of the use of the lance.

Bayonets were first made at Bayonne about the middle of the seventeenth century. Poigniards were the earliest weapons of this class, and were made with wooden handles fitting to the bore of the gun. A socket, by which it was fixed on the muzzle, was added subsequently, and in this improved form bayonets were first used by the French in the reign of William III., to the intense astonishment of our 25th Regiment of Foot.

The flint lock is of Dutch origin, and was invented in the reign of Charles II. It has undergone little essential alteration until within the last thirty years, during which latter period its modifications have been numerous and important.

Oddly enough, the idea of igniting gunpowder by the application of a fulminating substance first occurred to a clergyman—the Rev. Mr. Forsyth—in the year 1807. Although the subsequent experiments of Mr. Forsyth did not succeed according to his expectations, the idea set other minds to work, and a few years later one Joseph Egg invented the percussion cap. This was in 1816 ; but, strange to say, it was not until 1839 that they were used in the military service of England, and they were not adopted by the French until the following year.

It is popularly supposed that the rifled barrel is a modern invention. This is a mistake. Barrels were grooved by the Germans as early as the fifteenth century, and spiral grooves giving the ball a rotary motion were made at Nuremburg in the year 1620. The Poles were probably the

first to use rifles in military service, but it was not until the American war in 1794 that they were placed in the hands of English soldiers.

To enter into all the modifications of the rifle during the last quarter of a century would be to weary the reader with a mass of technical and for the most part uninteresting details. We may, however, allude to one notable improvement. The great difficulty of loading the rifle when the ball encased in a patch of leather had to be driven into the barrel with great force prevented its extended use until within the last twenty years, when the difficulty was surmounted by the substitution of bullets which expand in firing, and which do not require to fit the barrel closely in loading. This is the system adopted in the Enfield rifle now used in the English service. Among the inventors by whose efforts the rifle has been brought to its present degree of perfection may be named M. Deloigne, a French officer, Mr. Greener, of Birmingham, Colonel Thonvenin, Captain Minie, Sir Joseph Whitworth, Mr. Westley Richards, Mr. Snider, and Mr. Terry.

We may now proceed to notice in a few words the three chief small arms of the period—the Snider-Enfield, the Chassepot, and the Prussian needle-gun. These guns are all made upon the same leading principles, which are the breech-loading action and the substitution of a cartridge for the percussion cap. The Prussian needle-gun resembles the Chassepot in one important feature. The breech in either gun is opened by the pulling back of a bolt, which, when the charge is inserted, is pushed home and turned down. In the Snider another plan is adopted; a solid block is lifted out of the breech, the charge is inserted into the barrel in front of it, and the block replaced. The various ways of hinging this block and securing it when down form half of the varieties of breech-loaders. In one the block turns over to the right, in another to the left, in one backwards, in another forwards, all differing in some minor, though perhaps essential, detail, but the leading idea is the same. Two of these three fire-arms are now being practically tested in the greatest tourney the world has seen, with what results our readers are sufficiently familiar.

Birmingham and Liege are the great centres of the gun trade in Europe. In numbers Birmingham is outstripped by her Belgian rival, but in value and quality the "hardware village" carries off the palm. In 1864 the number of guns of all descriptions which passed the Government proof-house at Liege was as follows;—

Single guns	202,216
Double guns	96,616
African muskets	13,682
Saddle pistols	11,653
Pocket pistols	172,962
Military guns	177,751
Total	674,882

The statistics obtainable with regard to Birmingham produce during the same year (which we have selected as being an average year) are in less complete detail, but in the sum total they are 17 per cent. less than those of Liege. In aggregate value, however, the Birmingham guns produced in the same period show a superiority of more than one-fifth over those of its great Continental rival. The Government factory at Enfield, and the Small Arms Company at Small Heath, near Birmingham, now almost exclusively monopolize the military gun trade of Great Britain. At the latter establishment, which is the only one in Birmingham where guns are made on the interchangeable system, the present rate of production is 2,000 per week. The recent extravagant reports of guns produced in Birmingham for the French Government are falsified by the numbers quoted to all readers who are acquainted with the local capabilities of production. As a matter of fact, no guns are being supplied by Birmingham to either of the belligerent powers, unless it be by some artful stratagem of which the manufacturers are wholly ignorant.

The mitrailleuse field-piece is by this time too well-known to need description here. The central idea carried out in this terrible engine of destruction is the binding together of a large number of rifles mounted on a carriage, and by a mechanical appliance discharged simultaneously. This idea has been perfected with slight modifications, both by France and Germany, but the invention is by no means new to England, Mr. Goddard, of Birmingham, having submitted a design for a mitrailleuse gun to the English Government years ago, and before it was

known that the Continental powers had devised or even thought about any such weapon of warfare. With this combination gun we may for the present close these fragmentary notes on military fire-arms, only remarking that the achievements of modern science and the enterprise of modern industry have despoiled warfare in these days of its olden romantic chivalry, and rendered it little better than a system of wholesale murder by machinery.

IRON ARCHES.

(*Continued from page* 455.)

PROPOSITION VII.

To form the explicit value of M, for every point of the arch.

In the expression for M, arrived at in Proposition III., the value just indicated for H is to be substituted. It (the value for H) multiplies

$$R\,(\cos\theta - \cos\alpha)$$

PROPOSITION VIII.

To find the place where the bending moment is greatest.

Since a and b are supposed constant, M must be maximum at such place or places. Therefore, differentiating the expression for M, arrived at in Proposition III., and omitting the multiplier R, we get

$$0 = -(a\,b\,R + H)\sin\theta + a\,b\,R\,(\sin\theta + \cos\theta) + \frac{W}{2}\cos\theta,$$

or

$$0 = -H\sin\theta + a\,b\,R \times \theta\cos\theta + \frac{W}{2}\cos\theta.$$

This equation can only be solved in a numerical form. The point or points indicated by it correspond to maxima of the bending moment.

There is, however, another most important breaking point, which the investigation by evanescence of the differential coefficient fails to indicate; and the reason is very remarkable. In forming the value of M (Proposition III.), we have taken the mechanical movements of all the forces on the left of P, namely, of abutment reactions, and of weight of the arch on the left of P. If, in this manner, we investigate the bending moments, at successive points from A towards W, always taking forces on the left of P, we have still only abutment reactions and arch on the left of P. But if we continue on the same system of always taking forces on the left of P, as soon as we pass the weight we have the weight W in addition to the abutment reactions and arch on the left of P. Here is a new element introduced. In consequence of this, the function expressing M is discontinuous; $\frac{d\,M}{d\,\theta}$ changes *per saltum* at W, and we have no evidence from $\frac{d\,M}{d\,\theta}$ whether it is there maximum or not. Usually (not invariably) in such cases, M is maximum or minimum; and it is so here, being in maximum negative (as will easily be perceived from the nature of the forces' action), or tending to break the crown downwards with maximum force.

Example:

Let $\alpha = 60°$.

The equation in Proposition VI. for the determination of H will be found to give

$$H = a\,b\,R \times .785 = \frac{W}{2} \times 1.261$$

Substituting this value of H arrived at in Proposition III., we get for the bending moment M at any point, R$\times$the following quantity

$$(a\,b\,R \times 1.785 + \frac{W}{2} \times 1.261)\,(\cos\theta - \tfrac{1}{2}) +$$
$$a\,b\,R\,(\theta.\sin\theta - 907) + \frac{W}{2}\sin\theta - .866),$$

and in like manner the equation which determines the place of maximum bending moment (Proposition VIII.) becomes by substitution

$$0 = (-a\,b\,R \times .785 - \frac{W}{2} \times 1.261)\sin\theta +$$
$$a\,b\,R \times \theta.\cos\theta + \frac{W}{2} \times \cos\theta$$

To proceed further we must assign a numerical value to W, and we shall make three suppositions as follows:

Supposition 1.

Let $W = 0$

The equation for place of greatest moment becomes

$$-.785 \sin\theta + \theta\cos\theta = 0 \text{ or } \tan\theta = \frac{\theta}{.785}$$

The solutions of this are sensibly $\theta = 0°$ $\theta = 45°$
Hence the two breaking places are at $\theta = 0°$ $\theta = 45°$

The expression for bending moment becomes

$$M = a\,b\,R^2 \times \{1.785(\cos\theta - \tfrac{1}{2}) + (\theta.\sin\theta - .907\}$$

when $\theta = 0$ this becomes $M = -a\,b\,R^2 \times .014$
when $\theta = 45°$ it becomes $M = +a\,b\,R^2 \times .018$

(The negative sign in the first value of M denotes that the joint opens below).

Hence the weakest place is at 45°.

Supposition 2.

Let $W = R.\,a.\,b.$

(This is nearly, but not quite, the same as supposing that the load on the crown= weight of one-half of the arch).

One solution for the place of greatest bending moment is θ=0, the other is given by the equation

$$-1.416.\sin\theta + (\theta + \tfrac{1}{2})\cos\theta = 0 \text{ or } \tan\theta = \frac{\theta + 0.5}{1.416}$$

the solution of which is $\theta = 41°$ nearly.

The expression for bending moment becomes

$$M = a\,b\,R^2 \times \{2.416 \times \cos\theta + \theta.\sin\theta + \tfrac{1}{2}\sin\theta - 2.548\}$$

when $\theta = 0$ this becomes $M = -a\,b\,R^2 \times .142$
when $\theta = 41°$ it becomes $M = +a\,b\,R^2 \times .072$

Hence the weakest place is the crown of the arch. The bending moment at the crown is ten times as great as in supposition 1; that at the haunch is four times as great.

Supposition 3.

Let $W = 2\,R\,a\,b.$

(This is nearly the same as supposing that the load on the crown=weight of the whole arch.)

One solution for the place of greatest bending moment is θ=0. The other is given by the equation

$$-2.046.\sin\theta + (\theta + 1)\cos\theta = 0 \text{ or } \tan\theta = \frac{\theta + 1}{2.046}$$

The solution of this equation is $\theta = 39°$ nearly.

The expression for bending moment becomes

$$M = a\,b\,R^2 \times \{3\,046 \times \cos\theta + \theta.\sin\theta + \sin\theta - 3.296\}$$

when $\theta = 0$ this becomes $M = -a\,b\,R^2 \times .250$
when $\theta = 39°$ it becomes $M = +a\,b\,R^2 \times .128$

Hence the weakest part is the crown.

The bending moment is eighteen times greater than in supposition (1).

PROPOSITION IX.

To investigate the bending moment at any point of the arch when the weight is eccentric.

Let β be the angle which defines the position of the weight, as in the diagram; then the vertical forces K, K', at the abutments will become respectively

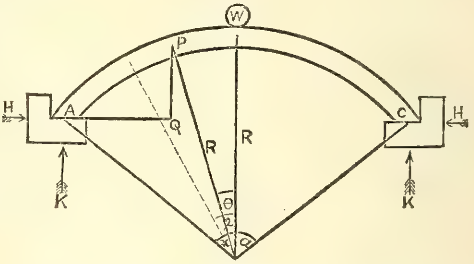
$$R.\,\alpha.\,a.\,b + W \times \frac{\sin\alpha + \sin\beta}{2\sin\alpha},$$

and

$$R.\,\alpha.\,a.\,b + W \times \frac{\sin\alpha - \sin\beta}{2\sin\alpha}.$$

The general principles of the investigation will be those of Propositions III. to V., but a peculiar caution is necessary, because the moments produced by the weight W have to be taken differently for points on its two sides. This apparent complexity might be avoided by measuring the moments in opposite directions on the two sides of W. The process will, however, be rendered more intelligible by always proceeding with the arc from the right abutment towards the left, and always taking the moments of parts towards the left.

FIG. 4.



Section (1). For a point between the right abutment and the weight: that is, for values of θ included between $-\alpha$ and $+\beta$.

The forces on the left hand of the point, producing moments about the point, are

The weight of the portion from the point to A.
The force H.
The weight W acting immediately.
The force $K = R\,\alpha\,a\,b + W \times \dfrac{\sin\alpha + \sin\beta}{2\sin\alpha}$.

The first three of these forces tend to bend A downwards and inwards, and the last to bend A upwards and outwards. They produce (nearly as in Proposition III.) the bending moment.

$$M_1 = \left\{\begin{array}{l} a.b.R^2(\cos\theta + \theta\sin\theta - \cos\alpha - \alpha.\sin\alpha) \\ +H.\,R.\,(\cos\theta - \cos\alpha) \\ +W\,R\,(\sin\beta - \sin\theta) \\ +W \times \dfrac{\sin\alpha + \sin\beta}{2\sin\alpha} \times R\,(\sin\theta - \sin\alpha) \end{array}\right\}$$

And, as in Propositions IV. and V., this moment, in the space $\delta\theta$, produces a curvature expressed by multiplying it by E

R. $\delta\,\theta$; and produces a spread of A expressed by multiplying it by

$$R\,(\cos\theta - \cos\alpha).$$

Hence, for the spread produced by the whole part between the right abutment and W, we have to integrate E. R.^{2} M_1 (cos θ — cos α) $\delta\,\theta$ from $\theta = -\alpha$ to $\theta = +\beta$.

Section (2). For a point between the weight and the left abutment; that is, for values of θ included between $+\beta$ and $+\alpha$.

On this section there is no force W to the left of the point: the bending moment is,

$$M_2 = \left\{\begin{array}{l} a\,b\,R_2\,(\cos\theta + \theta.\sin\theta - \cos\alpha - \alpha.\sin\alpha) \\ +H.\,R\,(\cos\theta - \cos\alpha) \\ +W.\dfrac{\sin\alpha + \beta}{2\sin\alpha} \times R\,(\sin\theta - \sin\alpha) \end{array}\right\}$$

and M_2, as before, is to be multiplied by ER. $\delta\,\theta$, and by R (cos θ—cos α), to find the spread which the bend in the small piece $\delta\,\theta$ produces. Hence for the spread produced by the whole section between the weight and the left abutment, we have to integrate M_2. E. R_2 (cos θ—cos α) $\delta\,\theta$ from $\theta = \beta$ to $\theta = \alpha$.

Then, as in Proposition VI., the total spread (the sum of the two integrals) is to be made$=0$; H will be determined from this equation, and its value must be substituted in the expressions for M_1 and M_2. The bending moment at any point of either section of the arch will then be obtained; it will have one maximum value where $\theta = \beta$, and one other maximum value in each section of the arch where $\dfrac{d\,M}{d\,\theta} = 0$.

The total spread of the foot A of the arch is thus obtained. The three integrals in Section (2) are similar to the 1st, 2d, and 4th integrals in Section (1); the latter are to be taken between limits $-\alpha$ and $+\beta$, and the former between limits $+\beta$ and $+\alpha$. The sum of the two parts of each integral, therefore, constitute integrals to be taken between limits $-\alpha$ and $+\alpha$. The result of the integration will give (omitting the general factor E. R^3),

$$(a\,b\,R + H) \times \{-3\sin\alpha\cos\alpha + \alpha\,(\sin^2\alpha + 3\cos^2\alpha)\}$$
$$+ a\,b\,R \times \{-\tfrac{3}{2}\sin\alpha\cos\alpha + \alpha\,(\tfrac{3}{2}\cos^2\alpha - \tfrac{3}{2}\sin^2\alpha) + \alpha^2\,2\sin\alpha\cos\alpha\}$$
$$+ W\frac{\sin\alpha + \sin\beta}{2\sin\alpha} \times (-2\sin^2\alpha + 2\sin\alpha\cos\alpha).$$

The 3d integral in Section (1) is to be taken only between the limits $-\alpha$ and $+\beta$. It will be found to give a result,

$$W \times \{\tfrac{1}{2} + \tfrac{1}{2}\sin^2\beta + \tfrac{1}{2}\cos^2\alpha - \cos\alpha.\cos\beta + \sin\alpha.\sin\beta - (\alpha + \beta)\cos\alpha.\sin\beta\}$$

And collecting all the terms, we obtain for the entire inwards spread,

$$E\,R^3 \left\{\begin{array}{l} H \times \{-3\sin\alpha.\cos\alpha + \alpha\,(\sin^2\alpha \\ \quad + 3\cos^2\alpha\} \\ +ab\,R \times \{-\tfrac{9}{2}\sin\alpha.\cos\alpha + \alpha(-\tfrac{1}{2}\sin^2\alpha \\ \quad + \tfrac{9}{2}\cos^2\alpha) + \alpha.{}^2\,2\sin\alpha\cos\alpha\} \\ +W \times \{\tfrac{3}{2}\cos^2\alpha - \tfrac{1}{2}\cos^2\beta - \cos\alpha.\cos\beta + \\ \quad (\alpha.\sin\alpha - \beta.\sin\beta).\cos\alpha\} \end{array}\right\}$$

(The following partial verifications are to be found on comparing this formula with that obtained in Proposition V.: (1) When $\beta=0$, its value is double that of the spread in Proposition V.; (2) The powers of (β) are even, as will be seen by expanding the functions of β; (3) When $\beta = \alpha$, the coefficient of W vanishes.)

Example:

Let $\alpha = 60°$ $\beta = 30°$

Then substituting these values of (α) and (β) in the last equation, we obtain

$$\text{Spread of A} = E.\,R^3 \times \{H \times .2718 - a\,b\,R \times .2134 - W \times .1104\}$$

and putting this $= 0$, we obtain

$$H = a\,b\,R \times .785 + .406$$

The absolute bending moment M_1, for any point between $\theta = -\alpha$ and $\theta = +\beta$, is found by substituting this value of H in the expression for M_1, and we shall find

$$M_1 = \left\{\begin{array}{l} a\,b\,R \times \{1.785\cos\theta + \theta\sin\theta - 1.800\} \\ +W\,\{.406\cos\theta - .211\sin\theta - 0.386\} \end{array}\right\}$$

The absolute bending moment, M_2, for any point between $\theta = +\beta$ and $\theta = +\alpha$ will in the same way be found to be as follows:

$$M_2 = \left\{\begin{array}{l} a\,b\,R\,(1.785\cos\theta + \theta.\sin\theta - 1.800) \\ +W\,(.406\cos\theta + .789\sin\theta - 0.886) \end{array}\right\}$$

The two formulæ agree when $\theta = 30°$ or under the weight W. We shall give no further attention to the second, as that side of the arch is the stronger.

To find where M_1 is a maximum, we must make $\dfrac{d\,M_1}{d\,\theta} = 0$. This will give us

$$a\,b\,R \times \{-1.785\sin\theta + \sin\theta + \theta.\cos\theta\} + W\{-.406\sin\theta - .211\cos\theta\} = 0$$

from whence we obtain

$$\tan\theta = \frac{a\,b\,R \times \theta - W \times .211}{a\,b\,R \times .785 + W \times .406}.$$

Let $W = R\,a\,b$. Then $\tan\theta = \dfrac{\theta - 211}{1.191}$.

This gives $\theta = -34°$ nearly. Substituting in the expression for M_1 above, we get

$$\text{when } \theta = +30° \quad M_1 = -.133 \times a\,b\,R^2$$
$$\text{when } \theta = -34° \quad M_1 = +.080 \times a\,b\,R^2$$

Therefore the bending moment is greatest for the point under the weight.

$$\text{Let } W = 2\,R\,a\,b. \quad \text{Then } \tan\theta = \frac{\theta - .492}{1.597}.$$

This gives $\theta = -31°$, and, as before, we get,

$$\text{when } \theta = +30° \quad M_1 = -.274 \times a\,b\,R^2$$
$$\text{when } \theta = -31° \quad M_1 = -.148 \times a\,b\,R^2$$

Thus in this case the bending moment is nearly twice as great for the point under the weight as for any other weight.

PROPOSITION X.

To investigate the bending moment at any point of the arch, when the piers present no lateral resistance.

In this case we have merely to make $H = 0$ in the expressions for M, and to enter into none of the calculations for spread. And in the numerical calculation it is only necessary to consider the point under the weight; and it is certain that, if W be not very small, the arch will break there.

If the weight be central, the value of M (Prop. III.) is R $\times$ the following expression:

$$a\,b\,R \times \{(\cos\theta - \cos\alpha) + (\theta\sin\theta - \alpha\sin\alpha)\} + \frac{W}{2}(\sin\theta - \sin\alpha)$$

when $\theta = 0$, this becomes

$$M = a\,b\,R^2 \times (1 - \cos\alpha - \alpha\sin\alpha) - R\frac{W}{2}\sin\alpha$$

and if $\alpha = 60°$, this becomes

$$M = -R\,(a\,b\,R \times .407 + W\,.433)$$

$$\text{Let } W = 0 \quad \text{then } M = -a\,b\,R^2 \times .407$$
$$\text{Let } W = R\,a\,b \quad \text{then } M = -a\,b\,R^2 \times .840$$
$$\text{Let } W = R^2\,a\,b \text{ then } M = -a\,b\,R^2 \times 1.273$$

If the weight be eccentric, the value of M_1 (Prop. IX.) is R $\times$ the following expression:

$$\left\{\begin{array}{l} a\,b\,R \times (\cos\theta + \theta\sin\theta - \cos\alpha - \alpha\sin\alpha) \\ + W(\sin\beta - \sin\theta) + W.\,\dfrac{\sin\alpha + \sin\beta}{2\sin\alpha} \times \\ (\sin\theta - \sin\alpha) \end{array}\right\}$$

and when $\theta = \beta$, this becomes

$$M = a\,b\,R^2 \times (\cos\beta + \beta.\sin\beta - \cos\alpha - \alpha\sin\alpha) - W.\,R.\,\frac{\sin^2\alpha - \sin^2\beta}{2\sin\alpha}.$$

And if $\alpha = 60°$ and β 30°, this becomes

$$M = -R\,\{a\,b\,R \times .279 + W \times .289\}.$$
$$\text{Let } W = R\,a\,b \quad \text{then } M = -a\,b\,R^2 \times .568$$
$$\text{Let } W = 2\,R\,a\,b \text{ then } M = -a\,b\,R^2 \times .857.$$

Table of results collected from Propositions VIII., IX., and X.

In the following formulæ the section of the arched rib is supposed to be a parallelogram of depth (b) and width (a), R is the radius of the arch at the middle of its depth. The whole arch is supposed to be 120 deg. of a circle, or 60 deg. on each side of the crown. When the weight W is eccentric, it is supposed to be 30 deg. from the crown, or midway between the crown and the springing. M is the bending moment at the point specified.

PART I.

The arch tight within the abutments, so that they receive the full horizontal thrust.

(1) No weight W	
At the crown	$M = -a\,b\,R^2 \times .014$
At 45° from the crown	$M = +a\,b\,R^2 \times .018$
(2) The weight central	$W = R\,a\,b$
At the crown	$M = -a\,b\,R^2 \times .142$
At 41° from the crown	$M = +a\,b\,R^2 \times .072$
(3) The weight central	$W = 2\,R\,a\,b$
At the crown	$M = -a\,b\,R^2 \times .250$
At 39° from the crown	$M = +a\,b\,R^2 \times .128$
(4) The weight eccentric	$W = +R\,a\,b$
Under the weight	$M = -a\,b\,R^2 \times .133$
At 34° from the crown on the opposite side	$M = +a\,b\,R^2 \times .080$
(5) The weight eccentric	$W = 2\,R\,a\,b$
Under the weight	$M = -a\,b\,R^2 \times .274$
At 31° from the crown on the opposite side	$M = +a\,b\,R^2 \times .148$

PART II.

The arch not confined horizontally between the abutments.

(1) No weight W	
At the crown	$M = -a\,b\,R^2 \times .407$
(2) The weight central	$W = R\,a\,b$
At the crown	$M = -a\,b\,R^2 \times .840$
(3) The weight central	$W = 2\,R\,a\,b$
At the crown	$M = -a\,b\,R^2 \times 1.273$
(4) The weight eccentric	$W = R\,a\,b$
Under the weight	$M = -a\,b\,R^2 \times .568$
(5) The weight eccentric	$W = 2\,R\,a\,b$
Under the weight	$M = -a\,b\,R^2 \times .857$

It will now be proper to apply the formulæ of the foregoing investigation to the circumstances of a practical example in order to show the importance of the bending moment when combined with the thrust force of the arch. The problem will be simplified as much as possible, and may be stated as follows:

Required the sectional dimensions for a continuous wrought-iron arch of 200 ft.

span (measured from centre to centre of the feet of the arch), and 30 ft. mean central rise: the section of the arch to have the form of a single rectangular cell of uniform thickness: the fixed load (comprising the weight of the arch itself and its proportion of the roadway) to be taken at 2 tons per foot run, and the running load at $1\frac{1}{4}$ tons per foot run?

With the above dimensions it will be found that the radius R = 181.666 ft., the half angle of the arch, α = 33 deg. 24 min. (circular measure of α = .5829), and length of arch = 211.8 ft.

We shall treat the case as if the arch were loaded uniformly all over its length; this supposition, though incorrect, will give us a close approximation to the circumstances of the actual case. It is usual to make the strengths sufficient to carry 3 times the fixed load + 6 times the running load. Hence in the case of the example the load per foot run will be $6 + 7\frac{1}{2} = 13\frac{1}{2}$ tons per foot run, or 2,700 tons in the aggregate: this load distributed over the arch will give a uniformly distributed load of $\frac{2700}{211.8} = 12.75$ tons per ft. of the arch.

We shall proceed to determine the strains from consideration of an arch having the same shape and size of the example, and of such sectional dimensions as to weigh 12.75 tons per ft. of its length. Taking 480 lbs. as the weight of 1 cubic foot of wrought-iron, the sectional area must be $59\frac{1}{2}$ sq. ft. It will be understood that the value of the sectional area is merely introduced in this form to suit the unit of weight (1 cubic ft. of iron) adopted in the preceding investigations, and as representing in such units the actual load of 12.75 tons per ft. run.

(1). To find the value of H, which will be the value of the thrust force at the crown of the arch.

Taking the formula for H, given in Proposition VI., and putting W = 0, as there is no weight, W, in the present example,

$$H \times \left\{\tfrac{3}{2}\sin\alpha\cos\overline{\alpha} - \alpha(\tfrac{1}{2}\sin^2\alpha + \tfrac{3}{2}\cos^2\alpha)\right\} = a\,b\,R \times \left\{-\tfrac{9}{4}\sin\alpha.\cos\alpha + \alpha\,(\tfrac{9}{4}\cos^2\alpha - \tfrac{1}{4}\sin^2\alpha) + \alpha.^2\sin\alpha.\cos\alpha\right\}$$

and putting $\alpha = 33°\ 24'$, the above equation will be found to give a result,

$$H + .0085 = a\,b\,R \times .0079 \text{ or } H = .93 \times a\,b\,R$$

(2). To find the place of maximum strain. The equation is found in Proposition VIII.

$$0 = -H.\sin\theta + a\,b\,R \times \theta\cos\theta.$$

or,

$$0 = -.93 \times \sin\theta + \theta\cos\theta.$$

This gives $\tan\theta = \frac{\theta}{.93}$, and the solution is found by trial to be $\theta = 26°$; $\theta = 0$ will also define a point of maximum strain.

(3). To find the bending moment, and the thrust force, at the points defined by $\theta = 0$, $\theta = 26°$.

The equation for the bending moment is found in Proposition III.; it becomes, putting W = 0, and substituting the value of H,

$$M = a\,b\,R^2 \times 1.93 \times (\cos\theta - \cos\alpha) + a\,b\,R^2 \times (\theta\sin\theta - \alpha\sin\alpha),$$

when $\theta = 0$ and $\alpha = 33°\,24'$. $M = -.0023 \times a\,b\,R^2$.
when $\theta = 26°$ and $\alpha = 33°\,24'$. $M = +.0054 \times a\,b\,R^2$.

Thus the bending moment is greatest at the point $\theta = 26°$, and its numerical value at that point is

$$M = .0054 \times a\,b\,R^2 = .0054 \times 59\tfrac{1}{2} \times (181.66)^2 = 10603.$$

The thrust force at the crown is $H = .93 \times a\,b\,R$, and the thrust force at the point $\theta = 26°$, will be $H \times \sec 26°$.

$$= .93 \times a\,b\,R \times 1.112 = 11177.$$

(The units being the ft., and the weight of a cubic ft. of wrought-iron.)

(4) To determine the dimensions of the section so as to bear the strain due to the thrust force and the bending moment without exceeding a maximum thrust of 12 tons per sq. in. at the compressed surface of the arch.

The best way to do this will be by trial, thus: We shall assume the depth and width of the section, and determine the thickness of the shell, so that the sectional area shall be greater than would be necessary to endure the thrust force only. Thus we shall assume the thickness in our example, so as to give a sectional area of $\frac{2391}{7}$ square in. (the thrust force = 11,177 cubic ft. = 2,391 tons) instead of $\frac{2391}{12}$ sq. in., which would be about the least that would resist the thrust force only. We shall then try if this section will endure the bending moment in addition without producing a greater additional strain at the parts furthest from the neutral line (on the compressed side of the arch) than 5 tons per sq. in.,

which, together with the 7 tons already assumed to be caused by the thrust force only, will bring the metal at the outside of the section to its limiting endurance of 12 tons per sq. in. This will be the first trial, and if the section will not resist the bending moment in addition to the thrust force, we must make a second trial with altered assumptions.

Let, then, the depth of the rib be 6 ft., and the breadth 4 ft., and let the uniform thickness be k; then the sectional area will be $20 \times 12 \times k = 240.k$ sq. in. nearly. Now the thrust force $=$ 2,391 tons, and the sectional area required to resist this force, allowing 7 tons per sq. in. is $\frac{2391}{7}$ $= 342$ sq. in., nearly. Therefore, $240 \times k = 342$, and $k = 1.425$ in. $= .11875$ ft.

Now, the moment of the forces resisting the bending moment, in the case of a cell section such as that assumed, is:

$$\frac{2\,t}{3\,f}\Big[a\left\{f^3-(f-k)^3\right\}+2\,k\,(f-k)^3\Big]$$

Where $t =$ strain of the metal at the outside of the arch on the compressed side, and $f =$ distance of the neutral axis from the same side of the arch. In the present case, the section being symmetrical, we have $f =$ half depth of rib $= 3$ ft.; also $a = 4$ ft., and $k = .11875$ ft. The above expression becomes $= 4.t$ very nearly. If we put this equal to the bending moment, we obtain $4.t = 10603$, and

$t = 2651$ cubic feet of iron per sq. ft. of section.			
$=$ 568 tons	"	"	"
$= 3.94$ "	"	sq. in.	"

Thus the total strain on the metal at the outside surface of the arch (where it is most strained) is $7 + 3.94 = 10.94$ tons per sq. in., which does not exceed the limiting strength of 12 tons. The arch is therefore safe, and the thickness of the shell might with safety be somewhat reduced.

It is worth while to notice by this example how exceedingly fallacious a result would be obtained, if the bending moment of the forces were neglected. If the arch had formed a larger segment of a circle, as, for instance, if it had been an arch of 120 deg. instead of 67 deg., the bending moment would have been far more serious, and, in such cases, a fairly approximate result would be obtained from consideration of the bending moment only of the forces, without taking any notice of the thrust force as affecting the strain on the material of the arch.

In the early part of this investigation it has been stated that, as regards the equilibrium of the portion of the arch between the point considered and the abutment, the bending moment and the thrust force may be conjointly represented by a single force acting at a point removed from the centre of the section. This resultant force has very little significance in the case of a continuous arch, for both the bending moment and the thrust force are met by similar forces supplied by the material of the arch; but in the case of the voussoir arch, which is unable to meet a bending moment except it be combined with a thrust force, it is indispensable to consider them together as represented by their resultant. This resultant will act at a point removed from the centre of the section by a distance $x = \frac{M}{S}$, where $M =$ the bending moment, and $S =$ the thrust force at the joint considered. By means of this formula the line of thrust may be laid down for a voussoir arch, with a degree of approximation depending on the depth of the voussoirs as compared with the span of the arch. The question as to how near to the surface of the arch the resultant may safely be permitted to approach, so that the arch may not fail by the crushing of the materials, must be decided empirically, as it depends much upon the elasticity of the stone. It is sometimes ruled that the resultant must for safety be kept within the limits of the middle third part of the depth.

It is not intended to pursue the theory of the arch beyond its most ordinary practical application as contained in the foregoing columns. There is no difficulty in applying the same method to elliptic and catenarian arches; but these are of rare occurrence as compared with the circular arches, and the investigation would be more laborious. In case, however, the investigation of such arches should at any time be necessary, it would be found advisable to use rectangular coordinates in working out the problem, instead of the polar co-ordinates adopted in the present paper. It has long appeared to the writer that a practical theory of the iron arch was much needed, for with such arches it is an object of great impor-

tance to avoid a superfluity of material. This is not the case with stone arches, which for the sake alike of solidity, cheapness, and convenience, are close-jointed over their whole surface, and, as a contingent advantage, they usually possess a great superfluity of strength when the span is moderate. Moreover, the stone arches have an additional source of strength in the close union which can be effected with the backing and the spandrel walls, and this is very valuable ; indeed an instance came before the writer where an entire horizontal row of voussoirs had fallen out of an arch over a stream in consequence of the undermining of the foundations, and yet the arch carried the traffic of a turnpike road without exhibiting any sign of weakness. This source of strength cannot easily be secured for an iron arch, but nevertheless such is the strength of the material and so great are the advantages of continuity that for large spans the continuous iron arch is without doubt the safest, lightest, and strongest form of arch that could be employed.

DUST FUEL.

From "Engineering."

Every year there are produced at our collieries thousands of tons of dust coal, and, although of this vast quantity some small proportion is effectively utilized either by conversion into coke or by being used in the manufacture of the so-called "artificial" fuel, yet by far the greater proportion is either thrown on the waste heap or sold at a mere nominal price. Now, we have here an enormous national loss. Coal dust is certainly, in many cases, contaminated by admixture with foreign matters, but these, if deleterious, can readily be removed by washing, and the dust coal remaining then possesses theoretically the same calorific value, weight for weight, as the lump coal from the same seam. Practically, however, this dust coal is at present regarded as little better than a waste product, and hence there goes on annually a loss which we may justly call "national;" for although it may, in the first instance, fall more directly upon the colliery owners, yet it undoubtedly becomes ultimately a loss to the nation at large, as does everything which diminishes the value of the mineral resources of the country. This being the case, one of the most important questions of the day is, how can this loss be best prevented?

The great thing to be done evidently is to give this coal dust a good marketable value, either by the general employment of processes which will convert it into fuel of a kind meeting with a ready purchase, or by providing means for its economical combustion either in the state in which it is raised from the mines, or after it has undergone a certain cleansing process. In the former direction something has already been done—and much more, no doubt, will yet be done—by the employment of coal-washing machines, and by the conversion of the washed products into coke or artificial fuel; but in the second direction, namely that of providing means for burning the coal economically in a state of dust, little of any real practical value has been done until within the last year or so. No doubt we have had plenty of arrangements of fire-grates, etc., for burning slack coal, but the coal of which we are now speaking is much smaller than that ordinarily known as "slack"—real *dust*, in fact, a material by no means easy to deal with, as those who have experimented on its use well know. No doubt, also, many methods of burning this dust coal have been proposed and tried, with varying degrees of success. The idea of using fuel in a powdered state is very far from being a novel one, and as long ago as 1831 a patent was taken out for one mode of burning such fuel, while between the date just mentioned and the year 1868, considerably over a dozen patents were procured for different modes of attaining the same end. But, as far as we are aware, none of these plans ever achieved such an amount of success as to warrant its extensive application, and we think that we may fairly say that the first really practical coal-dust furnace which has been produced is that constructed on the plans of Mr. Thomas Russell Crampton, which, for many months past, has been doing good service at Woolwich Arsenal.

It is now more than a year since we first

directed the attention of our readers to Mr. Crampton's plans; and since that time we have had many opportunities of examining carefully the various modifications and improvements which experience has enabled Mr. Crampton to introduce for the purpose of either simplifying his furnace or increasing its efficiency. This being the case, we are able to testify, from our own personal knowledge, to the vast amount of ingenuity, energy, and perseverance which Mr. Crampton has brought to bear upon the subject with which he had to deal. Now that a practical success has been attained, there can be no harm in recording that this success was preceded by no small number of failures of a more or less disheartening kind. The great difficulty to be overcome was to obtain a *continuously* good result. To scheme an arrangement by which coal dust could be burnt successfully for a few hours at a time, was a comparatively easy task; but to produce a furnace which could be kept going day and night for a week or more together, and in which, moreover, the heat was at all times under perfect control, was another and very different matter, notwithstanding that now that it *is* done, the whole affair may appear very simple. In the first place, there had to be devised means for supplying the coal dust to the furnace with regularity and at any desired rate; next, provision had to be made for mixing this coal dust thoroughly and equally with the air for supporting combustion; and, finally, there had to be schemed an arrangement of combustion chamber not likely to be damaged by the intense heat, and capable of being readily and cheaply kept in repair.

In the furnace now working at Woolwich, these various ends—none of them of easy attainment—have been fulfilled in a manner which we think we may say is practically perfect. The powdered fuel is fed from a hopper by a pair of smooth-feeding rollers, and the arrangement is such that these rollers always have a certain quantity of loose material to draw from, so that their supply is unaffected by any temporary sticking of the coal dust in the hopper, that may arise from the presence of moisture or other causes. The powdered fuel falling from the feed-rolls is distributed to a series of pipes, through which it is injected into the furnace by means of jets of air supplied by a fan. The idea of injecting coal dust by means of air jets is an old one, and Mr. Crampton lays no claim to be its originator. Early in his experiments, however, he discovered that different modes of introducing into the furnace the jets of mixed air and coal dust produced widely different results, and no small proportion of his researches was devoted to discovering the best mode in which this introduction could be effected. In the furnace now in use at Woolwich, the jets enter the combustion chamber horizontally, opposite the bridge, and by a simple—almost ridiculously simple—arrangement it is insured that the mixture of air and coal dust shall be perfectly equable throughout the entire width of the chamber. The combustion chamber itself is simply formed by placing a fire-brick bottom where the fire-grate is ordinarily situated, provision being made for tapping at intervals the slag which accumulates from the melting of the foreign matters mingled with the coal dust. The main body of the furnace in which the blooms to be heated are placed is of precisely the same form as usual, and the products of combustion, also, pass off to a chimney in the usual way. By means of a damper in this chimney the draught can be readily adjusted, so that, owing to the action of the air-jets, there is at all times a slight plenum within the furnace, and thus, even if the door be opened, the interior is not cooled by the rush of cold air. This is an important point, as all who have had the management of furnaces will understand.

Such is a general outline of the plans on which the furnace at Woolwich is constructed, and we must now speak of the results obtained. In the first place we may state as evidence of the perfection of the fuel-feeding arrangements that the furnace has turned out fifty successive heats, averaging 30 cwt. of blooms per heat, *without the handles governing the supplies of air and coal ever having been moved.* Next, numbers of heats have been turned out with a consumption of less than 5 cwt. of coal per ton of blooms, and the weekly averages during regular work have shown a consumption of but about 6 cwt. per ton of iron turned out, this being done it must be remembered with dust coal obtained by grinding common slack, costing several shillings per ton

less than the coal ordinarly used at the Woolwich furnaces. Besides being employed on regular work, various experiments have been made with Mr. Crampton's furnace for the purpose of showing the intense heat obtainable by the arrangement. Thus on one occasion there was placed in the furnace, in a pot, 25 lbs. of puddle bar made from $\frac{3}{5}$ coal blast and $\frac{2}{5}$ Staffordshire pig, and this puddle bar which contained 0.04 per cent of carbon was *melted* in one hour and 45 min., and was then run into a mould and cooled. The ingot was then reheated to a red heat and hammered out into a bar 2 in. sq.; and this bar on being tested showed a tensile strength of 22 tons per sq. in., this strength being the same as that of bars worked up in the ordinary manner from puddle bars made from the same materials. The 2 in. bar was then heated to a good welding heat, and drawn down into a bar measuring $2\frac{1}{2}$ in. by $\frac{5}{8}$ in., when it was again tested, the result showing a breaking strain of 32 tons per sq. in., and the piece tested stretching $\frac{3}{8}$ in. in a length of $1\frac{1}{2}$ in. before being ruptured. The $2\frac{1}{2}$ in. by $\frac{5}{8}$ in. bar was bent double when cold, without fracture, the edges being quite sharp, and, finally, the iron was analyzed and found to still contain its 0.04 per cent. of carbon.

In another experiment a quantity of turnings from the same quality of puddle bar, which had been worked through the furnace three or four times, was melted in 50 minutes and run over an iron plate, the molten iron making a "cake" having an area of about one square foot, and a thickness varying from about $\frac{1}{64}$ in. to $\frac{1}{4}$ in. This plate or casting—which is perfectly malleable—was exhibited by Mr. Crampton during the recent meeting of the Institution of Mechanical Engineers at Nottingham, and at the same time the various samples obtained during the other experiments were also shown, and attracted, as they deserved, much attention.

A third experiment consisted in melting in a pot 25 lbs. of blister steel, this melting being accomplished in 60 minutes; at least that is the time that the pot was allowed to remain in the furnace, but it is believed that the complete melting of the material was effected in a shorter period. Finally, a small pot of plate glass mixture, which was piled up into a cone and left uncovered, was placed in a comparatively cool part of the furnace, where, however, it was exposed to the direct action of the flame, the result being that the materials were melted down in 20 minutes. The color of the glass was perfect, a good evidence of the completeness of the combustion.

The results we have recorded above are, we think, entitled to the careful attention not only of those directly interested in the utilization of small coal, but also of all who are engaged in metallurgical pursuits, or in manufactures employing high temperatures. The melting of wrought iron in a furnace supplied with cold fuel and cold air is, we believe, absolutely unprecedented, and the fact that such a thing can be accomplished in Mr. Crampton's furnace is in itself a proof not only of the perfection of the combustion, but of the regularity with which the heat is maintained. The temperature required for the melting of the wrought iron is but little below that at which the destruction of the furnace lining would take place, and had there been any material variations of temperature above or below the desired point, there would on the one hand have been a destruction of the furnace lining, and on the other a delay in effecting the melting of the iron itself.

The success which has been attained by Mr. Crampton in the use of powdered fuel opens up a very wide field of research, and it is as yet impossible to say to what improved metallurgical or manufacturing processes it may give rise. Indeed, quite apart from its affording a means of utilizing what has hitherto been almost a waste product, the system possesses great importance, and it is our intention, in a future article, to point out some of the ends to which it may lead, and also to describe more fully the details of the arrangement which Mr. Crampton's laborious researches have led him to adopt.

INTERCOLONIAL RAILWAY.—The tender of Messrs. Ellis & Co., for the 20th section of this line, has been accepted by the commissioners for carrying out the undertaking. It is rumored that Bessemer steel rails are to be laid down for the permanent way of the line. Section No. 10 is to be relet. According to present arrangements, the whole line is to be finished by July 1, 1872.

THE USES OF THE BESSEMER METAL.

From "The Engineering and Mining Journal."

In this country but little use has been made of the Bessemer metal, save for the manufacture of rails, while in Europe it has been successfully applied to many other purposes, among which we may mention boiler making, and the construction of many running parts of machinery. It has generally replaced wrought iron, and not steel. The use of the misnomer steel has doubtless been the reason that this metal has not been applied to many purposes for which it appears to be better adapted than either cast-iron, wrought-iron, or steel. Cast-iron and crucible steel, though they are harder than wrought-iron, possess less tenacity; hence, for constructions intended to resist jars or strains, neither of these metals has of late years found any extended use. The only other metal formerly known possessed of sufficient tenacity for such purposes was wrought-iron, which, in the course of time, has gained for itself so high a reputation that much prejudice has to be overcome before people will use anything else. In fact, iron-men are noted for their conservatism, and we readily admit that they ought to be conservative, when we consider the vast interests committed to their charge, often involving numerous human lives, as well as large amounts of money.

By the pneumatic or Bessemer process it is doubtless possible to make a metal resembling steel so closely that for many purposes it could be substituted for it. But in practice we find that what is actually made differs very widely from steel, and comes into competition rather with wrought-iron. Let us keep this point fully in view, while we compare the relative merits of wrought-iron and Bessemer metal. Everybody knows that it is impossible to handle very large masses of iron at once in a puddling furnace; and hence, if we want a heavy piece of wrought-iron, it is necessary to weld together two or more blooms in order to get it. It is also notorious that blooms are too likely to contain slag and other impurities, to be directly used in the manufacture of wrought-iron articles. They must first be subjected to the process of hammering, drawing out, and welding. However carefully the process of welding is conducted, there is always a possibility of leaving the welds imperfect, and hence the product, though externally perfect, is subject to flaws in the interior, which render it liable to fracture under strains which it ought to resist with ease. Bessemer metal, however, can be cast in ingots of 5 tons each, free from slag, and capable of being used directly for the manufacture of heavy articles. In this case, instead of flaws from imperfect welding, such as occur in wrought-iron, we are liable to find defects in the form of bubbles. Practically, it has been found that bubbles are much more frequent close to the periphery of the ingot than nearer the centre, so that the external appearance of a Bessemer ingot furnishes us with a correct idea of its internal condition. It is, moreover, asserted that when bubbles occur in the interior, they are free from rust, and present clean metallic surfaces, which weld together perfectly when the ingot comes to be drawn out. A correspondent of the "Maschinen Constructeur" says that he has seen Bessemer metal used with great advantage for making the piston-rods of steam hammers which were used for hammering steel. Wrought-iron pistons and piston rods of the same dimensions were used up in a short time, by the change of the iron from a fibrous to a granular structure, in consequence of the repeated concussions to which they were subjected. Bessemer metal has also been used for locomotive axles with excellent results. Its use for this purpose, as well as for boiler plates, is continually increasing in Europe, though we have not yet heard of its application to either purpose in this country. The fact that it resists the oxidizing effects of a flame much better than wrought iron is a strong argument for its use in boilers. It is only about 13 years since the first introduction of Bessemer metal, and though its adoption for rail-making has been contested, step by step, until it proved itself far superior to other iron, it is now almost universally commended for that purpose.

It is scarcely to be expected, however, that because its merits for rail-making has

been recognized, its other uses will meet with no opposition. Boiler-makers, for example, who have been all their lives accustomed to the employment of wrought-iron, will not discontinue to use it at once —though in the long run a superior material is certain of adoption. A large number of the boiler explosions of which we hear so often, are doubtless due to the partial destruction of the iron by oxidation, in boilers which were originally equal to the task imposed upon them. This fact was fully proved in England, by evidence recently given before the committee appointed by Parliament to inquire into the cause of the alarming number of boiler explosions occurring annually in that country, and to suggest remedies. The sulphur contained in the soft coal, which is used almost universally in England, may cause the destruction of the iron to take place more rapidly there than it would in this country, where so much anthracite and wood are used. Still, this destruction is, in a great measure, due to the oxidizing effects of the flame, which Bessemer metal resists much better than wrought-iron. So that the conclusions of the English committee are almost equally applicable to this country. This, in connection with its greater tenacity, would seem to recommend especially the use of Bessemer metal for boilers, and will doubtless lead, before long, to its experimental adoption for that purpose in this country.

LECTURE ON STREAM LINES AND WAVES IN CONNECTION WITH NAVAL ARCHITECTURE.*

By W. J. MACQUORN RANKINE, C.E., LL.D., F.R.SS. L. and E.

From "Engineering."

The lecturer stated that his object was to give a brief summary of the results of some applications of the mathematical theory of hydrodynamics to questions regarding the designing of the forms of ships, and the mutual actions between a ship and the water in which she floats. The art of designing the figures of ships had been gradually developed by processes resembling those called "natural selection" and the "struggle for existence," in the course of thousands of years, and had arrived in skilful hands at a perfection which left little more to be desired, when the object was to design a ship that should answer purposes and fulfil conditions which had previously been accomplished and fulfilled in the course of practical experience. But cases now frequently arose in which new conditions were to be fulfilled, and purposes to be accomplished beyond the limits of the performance of previous vessels; and in such cases the process of gradual development by practical trials made without the help of science was too slow and too costly, and it became necessary to acquire and to apply scientific knowledge of the laws which regulate the action of the vessel on the water and of the water on the vessel. Amongst the questions thus arising were the following:—What ought to be the form of the immersed surface or skin of a ship in order that the particles of water may glide smoothly over it? And the form of such a surface being given, how will it affect the motions of particles in its neighborhood, and what mutual forces will be exerted between the particles of water and that surface? Practical experience, unaided by science, answers the first question by saying that the surface ought to belong to a class called "fair surfaces"—that is surfaces free from sudden changes of direction and of curvature—of which various forms have in the the course of ages been ascertained by trial, and are known to skilful shipbuilders. That answer is satisfactory, so far as it goes; but in order to solve problems involving the mutual actions of the ship and the water something more is wanted, and it becomes necessary to be able to construct fair surfaces by geometrical rules based on the laws of the motion of fluids, and to express their forms by algebraic equations. There were many very early attempts to do this; but not being based on the laws of hydrodynamics they resulted merely in the finding of empirical rules for reproducing when required, forms that had previously been

* British Association.

found to answer in practice, and did not lead to any knowledge of the motions of the particles of water or of the forces exerted by and upon them; and they had little or no advantage over the old process of modelling by the eye and hand, and of "fairing" the lines with the help of an elastic rod called a "batten." As regards this process, indeed, the mathematical methods about to be referred to are to be regarded, not as a substitute for it in designing the form of a ship, but as a means of arriving at a knowledge of the mutual actions between her and the water, which the old process is incapable of affording. The earliest method of constructing the figures of ships by mathematical rules based on hydrodynamical principles was that proposed by Mr. Scott Russell about twenty-five years ago, and since extensively practised. It consisted in adopting for the longitudinal lines of a ship curves imitated from the outlines of waves in water. The motions which surfaces formed upon this model impressed on the water were known to a certain degree of approximation. Those "wave-lines," however, although they were very fair curves in the sense already mentioned, were by no means the only fair curves, but were only one class out of innumerable classes of curves having the property of gliding smoothly through the water; and it was well-known in practice that vessels had proved successful whose lines differed very widely from wave-lines. It was therefore desirable that methods should be devised of constructing by mathematical rules, based on the laws of the motion of fluids, a great variety of curves possessing the property of fairness, and not limited to the wave-line shape. Such had been the object of a series of researches that had been communicated to the Royal Society at different dates since 1862. They related to the construction of what it has been proposed to call stream-lines. A stream-line is the track or path traced by a particle of water moving in a smoothly and steadily flowing current. If, when a ship is gliding ahead through the water with a certain speed, we imagine the ship to be stationary, and the water to be flowing astern past the ship in a smooth and steady current with an equal average speed, the motions of the ship and of the particles of water relatively to each other are not altered by that supposition; and it becomes evident that if the form of surface of the skin of the ship has the property of fairness, all the tracks of the particles of water as they glide over that surface are stream-lines, and the surface itself is one containing an indefinite number of stream-lines; or, as it has been called, a stream-line surface. It is also to be observed that when we have deduced from the laws of the motion of fluids the relations which exist between the forms of the stream-lines in different parts of the current, and between those forms and the velocities of the particles as they glide along different parts of those lines, we know the relation between the form and speed of a ship whose surface coincides with a certain set of those stream-lines, and the motions of the particles of water in various positions in the neighborhood of that ship. The lecturer then proceeded to explain and to illustrate by diagrams, the methods of constructing stream-lines. These methods were based upon the application to stream-lines in a current of fluid, of a mathematical process which had previously been applied by Mr. Clerk Maxwell to lines of electric and magnetic force. A current of fluid is represented on paper by drawing a set of stream-lines, so distributed, that between each pair of them there lies an elementary stream of a given constant volume of flow. Thus, while the direction of flow is indicated in many given parts of the current by the direction of the stream-lines, the velocity of flow is indicated by their comparative closeness and wideness apart, being evidently greatest where those lines lie closest together, and least where they are most widely spread. If, upon the same sheet of paper, we draw two different sets of stream-lines, these will represent the currents produced in one and the same mass of fluid by two different sets of forces. The two sets of lines represent a network; and if, through the angles of the meshes of that network we draw a third set of stream-lines, it can be proved from the principle of the composition of motions that this third set of lines will represent the current produced in the same mass of fluid by the combinations of the forces which, acting separately, would produce the currents represented by the first two sets of stream-lines respectively. The third set may be called the resultant stream-lines, the first two

the component stream-lines. Suppose, now, that a third set of component stream lines are drawn representing the current produced by a third set of forces, this will form a net-work with the previously drawn resultant stream-lines ; and a set of lines drawn through the angles of the meshes of this new net-work will represent the resultant current produced by the combination of the three sets of forces, and so on to combinations of any degree of complexity that may be required. In order to draw a system of stream-lines suited for the longitudinal lines of a ship, three sets at least of component stream-lines must be combined. One of these is a set of parallel straight lines, representing an uniform current running astern with a speed equal to the actual speed of the vessel. A second set consists of straight lines radiating from a point called a focus, in the fore part of the vessel, and they represent the diverging motion that is produced by the ship displacing the water near her bows. The third set of component stream-lines consists of straight lines converging towards a second focus in the after part of the vessel ; and they represent the motion of the water closing in astern of the ship. The resultant stream-lines thus produced present a great variety of forms—all resembling those of actual ships, having all possible proportions of length to breadth, and all degrees of bluffness and fineness at the ends, ranging from the absolute bluffness of a sort of oval to a bow and stern of any degree of sharpness that may be required. It has been proposed to call stream-lines of this sort *oögenous neoïds*, that is, ship-like lines generated from an oval, because any given set of them can be generated by the flow of a current of water past an oval solid of suitable dimensions. The properties of these curves were investigated in 1862. They have, however, this defect, that the absolutely bluff ovals are the only curves of the kind that are of finite extent : all the finer curves extend indefinitely in both directions ahead and astern ; and in order to imitate the longitudinal lines of a finer ended vessel a part only of some indefinitely extended curve must be taken. In 1870 an improvement in the construction of such curves was made by which that defect was overcome ; it consisted in the introduction of one or more additional pairs of foci, involving the combination of at least five sets of component stream-lines. By this device it is possible to imitate the longitudinal lines of actual vessels by means of complete closed curves without using portions of indefinitely extended curves ; and thus the knowledge of the motion of the particles of water, as shown by the stream-lines that lie outside the closed lines representing the form of the vessel, becomes more definite and accurate. The lecturer mentioned that the idea of employing four foci and upwards had been suggested to him by the experiments of Froude on the resistance of boats modelled so as to resemble the form of a swimming bird, for which purpose stream lines with four foci are specially adapted. It has been proposed to call such lines *cygnogeneous neoïds*, that is, ship-like curves of shapes like that of a swan. In such curves, when adapted to fine-ended ships, the outer foci, that is, the foremost and the aftermost, are situated in or near the stem and sternpost of the vessel, which are represented in plan by small horseshoe-like curves, as if they were rounded off at the corners, instead of being square, as in ordinary practice. The inner foci are situated respectively in the fore and after body. When the foci of the longitudinal lines of a vessel have been determined, the proportion borne by the aggregate energy of the motion impressed on the particles of the water to that of the motion of the vessel herself, can be approximately determined ; and it is found to range in different cases from one-half to the whole of the energy of the ship. A convenient empirical rule for the approximate displacement of a ship with a true stream-line surface has been incidentally obtained in the course of these investigations; it is as follows :—Find the positions of the two cross sections whose areas are each equal to one-third of the midship section, multiply five-sixths of the longitudinal distance between these cross sections by the midship section ; the product will not differ by more than 2 per cent. of its amount from the actual displacement if the ship is bounded by a true stream-line surface. This has been found by trial to hold for various forms and proportions ranging from a sphere to a very sharp wave-line. The lecturer next proceeded to explain the bearing of some of the mechanical properties of

waves upon the designing of vessels especially when these properties are taken in combination with those of stream-lines. It had long been known that ships in moving through the water were accompanied by trains of wave, whose dimensions and position depended on the speed of the vessel, but the first discovery of precise and definite laws respecting such waves was due to Mr. Scott Russell, who published it about twenty-five years ago. The lecturer now described, in a general way, the motions of the particles of water in a series of waves, and illustrated them by means of a machine contrived for that purpose. He showed how, while the shape of the wave advances, each individual particle of water describes an orbit of limited extent in a vertical plane. The periodic time of a wave, its length, the depth to which a disturbance bearing a given ratio to the disturbance at the surface of the water extends, and the speed of advance of the wave, are all related to each other by laws which the lecturer explained. He then stated that Mr. Scott Russell had shown that when the vessel moved no faster than the natural speed of advance of the waves that she raised, these waves were of moderate height, and added little or nothing to her resistance; but when that limit of speed was exceeded, the waves, and the resistance caused by them, increased rapidly in magnitude with increase of speed. His own (Professor Rankine's) opinion regarding these phenomena was, that when the speed of the vessel was less than or equal to the natural speed of the waves raised by her, the resistance of the vessel consisted wholly, or almost wholly, of that arising from the friction of the water gliding over her skin; and he considered that this opinion was confirmed by the results of practical experience of the performance of vessels. The wave motion, being impressed once for all on the water during the starting of the vessel, was propagated onward like the swell of the ocean, from one mass of water to another, requiring little or no expenditure of motive power to keep it up. But, when the ship was driven at a speed exceeding the natural speed of the waves that she raised, those waves, in order to accompany the ship, were compelled to spread obliquely outwards instead of travelling directly ahead; and it became necessary for the vessel, at the expense of her motive power, to keep continually originating wave motion afresh in previously undisturbed masses of water; and hence the waste of power found by experience to occur when a ship was driven at a speed beyond the limit suited to her length. This divergence, or spreading sideways of the train of waves, had a modifying effect on the stream-lines representing the motions of the particles of water. It caused them, in the first place, to assume a serpentine form, and then, instead of closing in behind the ship to the same distances from her course at which they had been situated when ahead of her, they remained permanently spread outwards. In other words, the particles of water did not return to their original distance from the longitudinal midship plane of the vessel, but were shifted laterally and left there, much as the sods of earth are permanently shifted sideways by the plough. The place of the water which thus fails to close in completely astern of the vessel, is supplied by water which thus rises up from below and forms a mass of eddies rolling in the wake of the ship. This was illustrated by a diagram. Lastly, the lecturer explained the principles according to which the steadiness of a ship at sea is affected by waves; and the difference between the properties of steadiness and stiffness. The mathematical theory of the steadiness of ships had been known and applied with useful results for nearly a century; but in the course of the last few years it had received some important additions, due especially to the researches of Mr. Froude on the manner in which the motions of the waves affect the rolling of the vessel. A stiff ship is one that tends strongly to keep and recover her position of uprightness to the water. A steady ship is one that tends to keep a position of absolute uprightness. In smooth water these properties are the same; a stiff ship is also a steady ship in smooth water. Amongst waves, on the other hand, the properties of stiffness and steadiness are often opposed to each other. A stiff ship tends as she rolls to follow the motions of the waves as they roll; she is a dry ship; but she may be what is called uneasy through excessive rolling along with the waves. The property of stiffness is possessed in the highest degree by a raft, and by a

ship, which, like a raft, is very broad and shallow, and whose natural period of rolling in smooth water is very short compared with the periodic time of the waves. In order that a ship may be steady amongst waves, her natural period of rolling should be considerably longer than that of the waves, and in order that this property may be obtained without making the vessel crank, the masses on board of her should be spread out sideways as far as practicable from the centre of gravity; this is called "winging out the weights." A vessel whose natural period of rolling in smooth water is only a little shorter or a little longer than that of the waves, has neither the advantages of stiffness nor those of steadiness, for she rolls to an angle greater than that of the slope of the waves; and her condition is especially unsafe if her natural period of rolling is a little greater than that of the waves; for then she tends to heel over towards the nearest wave crest, to the danger of its breaking inboard. This is called rolling "against the waves." The most dangerous condition is that of a vessel whose period of rolling in smooth water is equal to that of the waves that she encounters; for then every successive wave makes her roll through a greater and greater angle, and under these circumstances no ship can be safe, how great soever her stability. All these principles have been known for some years, through Mr. Froude's researches. The lecturer exhibited a machine which he had contrived for illustrating them, in which the dynamical conditions of vessels of different degrees of stiffness and steadiness were approximately imitated by means of a peculiarly constructed pendulum, hanging from a pin whose motions imitated those of a particle of a water disturbed by waves. He concluded by thanking the members of the Association for the attention with which they had heard him.

THE Elevated Railway in Greenwich street is not at present in operation. It is currently reported that some motive power is to be substituted for the stationary engine and endless rope.

THE caisson of the East River Bridge is sinking gradually to its place. It is now at the depth of 36 feet. The depth proposed is 45 feet below high water.

RAILWAY NOTES.

FROM the "New York Tribune" of Oct. 31, we extract the following historical reminiscences of the railway locomotive:

Eighteen hundred men make a locomotive engine in one day—boiler, cylinders, frame, driving-wheels, truck, stack, cab, pilot, and tender, complete—the speed of 40 miles an hour and the power of a thousand tons created in a day.

On the 25th of April, 1831, a miniature locomotive engine, drawing two cars with seats for four persons, was set in motion on a track laid in the rooms of "Peale's Museum," in the city of Philadelphia. Great numbers of people, not only from the city but from distant parts, visited the Museum to witness the performances of this wonderful machine. Previous to that date only three attempts had been made in the construction of locomotives by American mechanics. Two engines, the "Phœnix" and the "West Point," had been built at the West Point Foundry, in 1830, for the South Carolina Railroad, and a third, the "DeWitt Clinton," for the Mohawk and Hudson Railroad, was completed in the spring of 1831. Two locomotive engines had been imported from England, one in 1828, for the Carbondale and Honesdale Railroad in Pennsylvania, and another for the Mohawk and Hudson Road, in 1830. The little engine amusing the visitors at Peale's Museum was the invention and work of Mr. Matthias W. Baldwin, then a skilful and enterprising mechanic of Philadelphia.

The following year Mr. Baldwin received an order from the Germantown Railroad Company for a locomotive for their road.

The difficulties to be overcome required an unusual degree of persistence and a masterly skill. Mr. Baldwin proved equal to the task, and in six months produced the "Ironsides." Its success was complete, the reputation of the builder was assured, and the foundation of a new branch of industry established.

Up to 1834, five engines had been built at this little shop; the next year produced fourteen, and the next forty. Now the Baldwin Locomotive Works can produce a complete locomotive for every working day in the year.

The improvements upon the manufacture of 1834 are of course almost numberless. Many of these are due to the maker of the "Ironsides;" and quite a large proportion of the most valuable were not reserved to the inventor's own use by patents, but were given to the public; more reliance being placed in superiority of skill and workmanship than in Letters Patent, to maintain the leadership in American production.

The Baldwin Locomotive Works are located on North Broad street, Philadelphia, and occupy the greater part of three blocks, from Pennsylvania ave. to Spring Garden st., and an area of 240,000 square feet. On the centre of the Broad street front stands the old shop, three stories in height, erected by Mr. Baldwin in 1834. Here are the offices, store-room and drawing department, and also what is called the Hamilton street shops, including boiler shop, smith shop, brass foundry, "first, second, and third story machine shops," and pattern loft. South of this building is the Willow street shop, where cylinders and frames are finished, and tanks, trucks, stacks, and cabs are made. Adjacent to this building on the west is a

brick building 266 ft. long, 60 ft. deep in the central part, and with two wings 108 ft. deep at either end. The central part of the building and the east wing are used for the iron foundry, where all the cast-iron work used about a locomotive, except the truck wheels, is made. The west wing is used as a hammer shop. One large steam hammer, rated at 5,000 lbs., is in constant use here, working up scrap and bar iron into blooms from which the engine frames are made. On the north side, beyond Buttonwood street, is the erecting shop, whither all parts tend, and whence complete locomotives emerge. Two large buildings and a lot of ground, detached from the main establishment, are employed as a blacksmith shop, stable, and storage room, not enumerated in the above.

The different varieties of locomotives usually manufactured in the establishment are technically designated in the Baldwin classification by certain letters and numbers. The letters indicate the plan or kind of engine; the numbers, the size or weight. The combination of the letters and numbers indicates precisely the class. To explain more clearly, the letter B is used to designate all engines having a single pair of drivers; C, those with two pairs of drivers; D, those with three; and E, those with four pairs of drivers connected. Then certain numbers, now merely arbitrary, but originally intended to indicate the weight of the machine in gross tons, are joined with the letters, and the combination designates a particular plan and size of locomotive. The ordinary type of the American locomotive, it is well known, is an engine on eight wheels, four of them under the fire-box part of the machine, and acting as "drivers," and four smaller wheels combined into a truck to carry the forward part of the engine. Such an engine in the Baldwin technicology, would be a "C" engine, by virtue of its having *two pairs of drivers connected.* If its cylinders are 16 in. in diameter, the boiler must be large enough to furnish them with steam, and all the other parts of the machine must conform in size. The aggregate weight of the engine is accordingly governed by the dimensions of the cylinders. Now the figures 27½ indicate these facts. We have then the combination 27½ C to designate a locomotive with eight wheels, four of them drivers, with cylinders 16 in. in diameter, and a certain aggregate weight for the whole machine. In like manner all the other classes of engines are appropriately designated.

From these classes and varieties the customer makes choice. Perhaps because of some special service, special modifications are required; these are noted and the price is agreed upon. The purchaser goes to his home, and his order to the "drawing department." Here the engine is, as it were, analyzed and dissected. The proposed machine, existing as yet only in imagination, must be composed, it is found, of a certain definite number of parts. The smith shop accordingly receives a written order, in a book provided for the purpose, to make the forgings, the foundry the castings, the boiler shop the boiler, and so on. The several machine shops also have their orders to fit up and finish these several parts which may come to them from the other departments. But not only is the bare order to do the work thus made, the manner in which it is to be done is also provided for. Drawings and patterns are already in existence for every one of the parts to be constructed, unless the engine is of a class never before built. These drawings and patterns all have their separate distinguishing numbers. Each order for the production of any part, or for the finishing or fitting of it, bears also the number of the drawing or pattern to which the work is to be done. These order-books and the necessary plans and patterns now go to the several departments, and with the fulfilment of the orders which they communicate must result all the parts required for the complete locomotive.

Every department of this great establishment is perfectly organized. Materials and men are classified. Every piece in its transition from crude stock to finished work, has its appointed place, and workmen. Everything is tested rigorously by exact measurement, so that broken parts of working engines may be supplied from the verbal description.

During the past twelve months, 271 complete locomotives have been sent from this shop, as follows: In October, 1869, 22; in November, 26; in December, 22; in January, 1870, 21; in February, 21; in March, 21; in April, 21; in May, 23; in June, 23; in July, 23; in August, 24; in September, 24. This is certainly a decided progress from the five engines turned out by Mr. Baldwin in 1835. But the progress which has been made in the methods of construction, resulting in increased efficiency, strength, speed, economy in fuel, and in repairs, is no less wonderful. The archives of the establishment, containing, as they do, communications covering a period of thirty-five years, and in the handwriting of railroad managers, engineers, and master mechanics, are not only a reflex of the general progress of railroad practice, but bear strong testimony to the efficiency and durability, and superior workmanship, for which the Baldwin engine has achieved an enviable reputation.

We cannot leave this subject without a word of comment on the lesson it teaches as to the value of American manufactures and the importance of fostering and protecting them.

Here is an establishment, the value of the finished products of which, in 1869, was $3,430,018.84. Of this sum, $1,068,388.20 was expended for labor, giving employment to 1,600 or 1,700 men, and, if we allow 5 persons to a family, furnishing a support for a population of 8,000 to 9,000 souls—no inconsiderable portion of the population of Philadelphia. But, further, the remaining two and a half millions represent the amount expended for materials, for tools, for railroad, canal, and steamer freights, for the innumerable incidental expenses of carrying on such a business, and for the return on the capital invested. But of this expenditure for material, bought and used in the manufacture of locomotives, all, without an exception, save some few articles not produced in this country, are exclusively American products or American manufactures. American boiler plate, American steel, American pig and bar iron, American lumber, American coal, American copper, and American brass, are the principal materials from which the Baldwin Locomotive Works construct their machines. All these articles, as they come to the works, represent in their cost price principally labor, and American labor at that—labor in mining coal, in smelting iron, in rolling boiler plate, in cutting and sawing lumber, etc. If we go back to the absolute first cost, or the royalty, for the coal and ore in the ground, and the lumber in the forests, as we logically may, we shall have but a few thousand dollars as the original first cost for the raw material, which mined, smelted, cast, forged, planed, turned, finished, and polished, stands

finally on the books at an aggregate value of nearly three and a half millions of dollars, and in its various stages of transformation and progress has given employment to probably 6,000 men, and supported a population of 30,000 souls.

These facts speak for themselves. But still another consideration is to be added; America competes with England in the manufacture of locomotives for foreign countries. Baldwin engines are at work in Germany, in Canada, in Cuba, in Brazil, in Peru, and in the Argentine Republic, and have been placed there, if not at less cost, at least as cheaply as English locomotives could have been. But English iron is only a fraction of the cost of American iron, and English labor brings wages barely sufficient to keep soul and body together. English pig-iron costs to-day $14 to $16 per ton; American pig-iron, $32 to $33 per ton. With equal prices for locomotives and machinery in the two countries, what is the inference? Clearly, that while in Europe capital extorts the lion's share as its return, here, where wages and the cost of material are both so much higher, it is labor—adequately paid, making possible comfortable homes, education, self-improvement, self-respect, and an intelligent citizenship—which stands foremost in the value of the finished product.

IRON AND STEEL NOTES.

Mr. Wm Lewis, who has been for the past four years connected with the Spuyten Duyvil Rolling Mill Company, at Spuyten Duyvil, N. Y., as the superintendent of their mills, was presented by the employees of the Company, on the occasion of his retiring from the position, with a handsome gold watch and chain, on which was inscribed the following: "Presented by the employees of the Spuyten Duyvil Rolling Mill, to Wm. Lewis, Superintendent, as a token of respect. Oct. 29, 1870."

Mr. Lewis goes to Columbia, Pa., where he is to take charge of the Columbia Rolling Mill.

The Weardale Iron and Coal Company, England, have almost completed their two large blast furnaces at Weardale. The furnaces are 85 ft. in height, 26 ft. at the bosh, and 7½ ft. in the hearth. The body of each furnace rests on 12 cast-iron columns, capped by an annular plate. The furnaces are cased with wrought-iron plates, of uniform diameter to the top externally; they will be closed at the top by the cup and cone. The down-pipe to withdraw gas from each is 3½ ft. in diameter, joining to the main gas-tube, 5½ ft. in diameter; these are of wrought-iron, not lined internally. Immediately behind each furnace, six stoves with cast-iron pipes are built, in two rows. Between these rows the wrought-iron pipes to supply gas to the six stoves are fixed. Each stove contains 14 double cast-iron pipes, 16 ft. in length, placed in two rows; each pipe is 19 in. by 5 in. in section; the blast having to pass through one row of these pipes, or 14 lengths of single pipe, before it makes its exit. Each stove is provided with its own chimney; the main blast-pipe is 6 ft. in diameter. Behind the stoves one large coke-hopper is built for each furnace, and a gantry, under which limestone and other material is stocked. Behind this a line of five calcining kilns are in course of erection; these are 45 ft. in height, plated externally, 20 ft. inside diameter, and will have self-acting delivery at the bottom of the kilns. The top of these and the gantries are approached by locomotive roads. The furnace-lift is on the water-balance principle—one carriage ascends while the other descends. The water-tank is fixed 20 ft. above the platform level. Three blowing engines, acting independently, and non-condensing, are erected in one building. Each engine (the cylinders being vertical, the blowing-cylinder at top and the steam-cylinder under it) rests on two cast-iron standards.

These engines are from the works of Cochrane, Grove & Co., Middlesborough. Each blowing cylinder is 84 in., steam cylinder 40 in. in diameter, placed 6 ft. below the blowing cylinder; stroke 5 ft.; the trunk at the top of the steam cylinder is 18 in. in diameter; from this by a cross-head and two connecting rods, motion is given to the fly-wheel shaft, and two fly-wheels of 7 tons each, all within the standards. One eccentric gives motion to two piston valves. The extreme height of the engines from the foundation is 25 ft. The blowing-cylinders are enclosed with sheet-iron, and by means of a pipe to the outside of the building the suction-valves will draw air from the exterior. The engines are designed to go from 20 to 30 strokes per minute; at the ordinary rate of 20 strokes each engine will supply 7,600 cubic feet per minute, and at the maximum, 11,400 cubic feet. In the same building two engines are erected, to supply water for the furnace lift and the tuyeres; each engine works two double-acting pumps with a plunger. There are also two smaller engines erected to feed the boilers. Eight plain cylindrical boilers are being fixed, 75 by 5 ft., each suspended from five arched girders, resting on cast-iron pillars, 5 ft. in length. The boilers will be heated entirely with gas from the furnaces. The chimney is 130 ft. in height.—*Bulletin of Am. Iron and Steel Association.*

ORDNANCE AND NAVAL NOTES.

Captain Harvey's Torpedo.—A most important and interesting trial of a sea torpedo was made on Monday, the 25th ult., in the offing at Plymouth. The Commander-in-Chief, Admiral Sir H. Codrington, K. C. B., Captain the Hon. F. A. Foley, Captain Jones, Captain Napier, Commander Harvey (the inventor), and other naval authorities were present on board the gunboat "Pigeon." The first torpedo on the port side, was used against the hulk "Sea Horse," the gunboat crossing her stern and the torpedo striking her port amidships about 10 ft. below the water line. No. 2 torpedo, on the starboard side, was towed against Her Majesty's brig "Squirrel," under canvas in the offing, and striking her on the port quarter, came up under her bows. No. 3, towing to starboard, was then brought down upon the turret-ship "Prince Albert," at shell practice, further out; the gunboat crossed the ship's bow, and the torpedo struck her port bow, 8 ft. under water, and passing under the bottom, came up on the starboard bow. With No. 4, to port, also used against the "Prince Albert," the tow-line passed over the ship and was allowed to run out to the end; the bight was then thrown clear and the torpedo came up from under the bottom. This was occasioned by no fault of the apparatus, but from want of speed in the gunboat at

the moment of collision. No. 5, to starboard, was used against the brig "Squirrel," and, striking her on the starboard bow at 8 ft. under water, came up under the starboard quarter. Several other attacks were then made on the turret-ship "Prince Albert," in every conceivable direction, and in almost every instance with complete success, as the capsule was found to be pierced after every contact, showing that had the torpedoes been loaded with an explosive compound the destruction of the vessels struck must have ensued. The trial, although quite sufficient to show the principle and accuracy of this formidable weapon, would have displayed its precision more prominently had the towing been performed by a faster vessel than the "Pigeon," which steams only six knots, whereas it should be a speed of eleven knots, at least, to insure good steerage to the torpedo and its sharp contact with the opposing vessel. The Russian Government are before us in adopting this terrible engine of war, as 20 of these torpedoes have already been supplied, and are being used for practice by the Russian war steamers on the Baltic. Several interesting experiments were also made with small quantities of explosive compounds, and by the results one could imagine the frightful effect of 100 lbs. (the torpedo's charge) exploding with upward tendency under a ship's bottom. The Commander-in-Chief and other officers went on board the turret-ship "Prince Albert" during a great part of the time, so as to witness the approach of the torpedo from this point of view.

THE LYMAN ACCELERATOR GUN.—Some time back we referred to the construction of the gun known as the "accelerator," in which a series of chambers were arranged at the side of the bore for containing charges of powder, which exploded in succession as the projectile moved along it towards the muzzle until the combination of the charges exerted their full force upon the base of the shot to throw or propel it. The gun tried was of small calibre, about 4 in. diameter, and this succeeded beyond the expectations of the company who were present to witness the trial. The success of the small one led the gentlemen interested in its production for field or battery purposes to endeavor to have one of a large size cast. Of course, many difficulties had to be overcome before they could venture to make the world acquainted with the fact that a large one was in hand, but after several failures, mainly due to unforeseen circumstances, they have had one cast weighing 10,175 lbs., and measuring 11 ft. 6 in. in length. This gun was tried in the United States a few miles below Reading, Pennsylvania, on the old proving ground.

The cannon was fired three times during the morning of June 29. The charges were as follows:

1st round, 1 lb. of powder in breech.
" 4 " " each pocket.
" weight of ball, 57 lbs.
2nd round, $1\frac{1}{2}$ lbs. of powder in breech.
" 6 " " each pocket.
" weight of ball, 77 lbs.
3rd round, 2 lbs. of powder in breech.
" 8 " " each pocket.
" weight of ball, 100 lbs.

The powder used for the breech was navy mammoth powder, and that for the four chambers or pockets along the bore was navy cannon powder, of 1,495 initial velocity and 991 density, Dupont's make.

The last round was a full proof charge, as intended for this gun, the heaviest charge ever placed in a cannon of the same calibre. After each round the diameter of the bore was carefully measured, but not the slightest increase could be discovered. The gun has so far given entire satisfaction. The balls were fired into a sand bank backed by logs, among the latter of which the balls lodged themselves about 4 ft. from the ground. The cannon was placed on a skid, and the charges were so heavy that the gun vibrated for several minutes a distance of some 35 ft. after each charge.

On the 30th some further trials were made, which completely tested the strength of the gun. Two rounds, each with 30 lbs. of powder and a solid shot weighing 100 lbs. were fired. So far the gun is a complete success in all its parts. No perceptible enlargement has taken place in the bore, and no part of the gun has been strained or worn by the action of the powder-gas or the balls. The shot used on this occasion could not be found after the firing, they having passed through 18 ft. of moist sand and imbedded themselves in the barricade of logs beyond the sand.

We understand that in a few weeks the gun will receive further proof with a view to ascertain the distance it will throw a 100-lbs. shot. The calculation is that it will reach a range of ten miles, and pass through at short range a wrought-iron target 15 in. thick. The powder used in the breech or bottom of the bore is encased in copper, and the wad, which is $4\frac{1}{2}$ in. thick, and made of bookbinder's heavy brown paper, is also attached to a copper plate.

The thickness of the metal of the gun along the pockets at the reinforce, is equal to the calibre, and along the neck, near the end of the muzzle, $3\frac{1}{2}$ in. The thickness of the metal of the pockets is one calibre.

This cannon has already been put to a severer test by the extraordinarily heavy charges, than any other gun heretofore made. In the Parrott rifled cannon, one of the most successful guns, only 8 lbs. of powder and a ball weighing 80 lbs. are used, while in this one 34 lbs. of powder and a ball weighing 100 lbs. are employed. Both these guns are rifled and are of the same calibre and weight. It was the universal opinion, excepting among the projectors of the gun, that the Lyman cannon would prove a failure, that it could not possibly stand the heavy proof charges destined for it.

The Lyman accelerator gun performed handsomely while under proof, and this fact may cause a revolution in the mode of constructing heavy ordnance.

The trials were under the directorship of Alban C. Stimers of New York, late naval engineer in the U. S. Navy, by whom the cannon was designed; Messrs. Samuel K. Wilson, of Trenton, N. J.; James R. Haskel, of New York; Captain W. R. M'Manus, and W. H. Robinson.

Further trials are ordered by the U. S. Government, and when these are completed the gun will be brought to England to be tested by the War Office authorities.—*Mechanic's Magazine.*

COLONEL MAXWELL, R. A., Superintendent of the Cossipore Gun Foundry, after comparing the French and Prussian field-guns, in a letter to the "Times," concludes by saying:—"I fearlessly and dispassionately assert that the 9-pounder muzzle-loading gun which we have lately adopted is the most powerful field-gun of its size in Europe; that

in a few weeks we shall be provided with a trustworthy concussion fuse for bursting both common shell and shrapnel on graze when the ground is favorable; that we have already the best time fuse in existence for bursting shells in the air, under proper circumstances; that this gun and its ammunition can in nowise go wrong, and that we may confidently send it into the field to meet any field-gun in existence of its size. But we must learn to fire deliberately, and apply reason, based on experience, in teaching our gunners their art." The "Times," in a long article on the subject of field artillery as illustrated by the operations of the present war, asks:—"Are we to rest satisfied with 12-pounders as the highest calibre of British field artillery capable of being carried with an army making forced marches, and able to be transported rapidly from place to place on the field of battle? If so, we should find ourselves opposed by artillery of higher calibre in case of war with either Prussia, Austria, or Russia. The Prussians have 15-pounders, the Austrian field-battery gun throws a projectile of nearly 16 lbs. weight, and the Russians have a field piece weighing little more than 12 cwt., considerably less than the English smooth-bore 9-pounder which we had in the Crimea, yet throwing a projectile of more than 25 lbs., with a velocity of 1,050 ft. per second."

ENGINEERING STRUCTURES.

New Bridge across the Mississippi.—From a late Detroit paper we make the following extract:

A short time since, the Detroit Bridge and Iron Company were awarded the contract for building an iron railroad bridge at Hannibal, Mo., over the Mississippi river, the contract price being about half a million of dollars.

The bridge crosses the Mississippi river at the city of Hannibal, Mo., and will connect the lines of railway built and being built to the river at that point. It is being constructed in the interests of four lines of railway: The Toledo, Wabash & Western, extending from Toledo, Ohio, to the east side of the Mississippi river at Hannibal; the Hannibal & Naples railroad, which is leased to the T., W. & W. railway and forms the western end of the line as above; the Hannibal and Moberly railroad, now being built from Hannibal, westward, to connect with the North Missouri railroad at Moberly; and the North Missouri railroad, extending from Moberly westward to Kansas City, connecting there with the Kansas Pacific and the various other lines of railroads in Kansas. All of the roads mentioned above are complete and in operation except the Hannibal & Moberly, which is now being rapidly constructed and will be finished within a year. A glance at the map will show the directness of the great through line thus formed between the East and the West, and the important influence it must exert as an artery of the national commerce.

No location on the Mississippi river could be selected more favorable for bridge purposes than at Hannibal. The channel is narrow, well defined, direct, and permanent. The river bed is well adapted for reliable and economical foundations, and the current is not rapid.

The precise point selected, after careful surveys, is about half a mile above the central part of the city. Here the river is hemmed in on the west by a high, precipitous, rocky bluff, along which runs the main channel, and on the east, a wide, flat bottom land spreads out to the opposite bluffs, about five miles away. Through this bottom wind many bays and sloughs, so called, through which the water in freshets finds abundant passage.

The bridge proper consists of four fixed spans of 180 ft. each: one fixed span of 250 ft.; one pivot draw span of 360 ft.; and one fixed span of 250 ft., in the order named, a total of 1,580 ft.

The masonry of piers and the foundations thereof will be of the best character. The west abutment is bedded on the solid rock. From thence, going eastward, the rock dips gradually, so that while it is exposed to the surface on the west side of the river, on the east side it is about 80 ft. below the surface. This is overlaid by sand, so that in the main channel the depth of water at the lowest stage is about 24 ft., and gradually decreases thence to each shore. The difference between high and low water is 22 ft. At high stage the bottom lands on the east side of the river are overflowed, and the surface of the water then is several miles wide.

The west pier and the massive pivot pier adjoining are placed upon piles driven through the sand to a firm bearing on the solid rock. The other piers and the east abutment are also placed upon piles, but these do not reach the rock. To prevent scouring, each pier and its foundation will be protected by riprap.

Each pile is to be so firmly driven as not to move more than one-quarter of an inch at the last blow of an iron hammer weighing 2,500 lbs. falling upon it from a height of 25 ft. The number of piles under the pivot pier is about 200, and under the other piers about 70 each. They will be driven into the sand about 22 ft., thus requiring piles from 40 to 50 ft. in original length. These are all of oak, hickory, or other approved hard wood, perfectly straight and sound, and not less than 8 in. in diameter at the small end. After being thus driven, they are cut off truly level at the bottom of the river, and the sand dredged away about their heads for a few feet in depth, the hole thus made in the river bed being filled with concrete.

Upon the heads of the piles thus placed, and the solid concrete bed surrounding them, the masonry is lowered in caissons or by screws. This process obviates the necessity of the old-fashioned expensive and dangerous coffer-dam, and foundations are thus placed with comparative ease and certainty in a depth of water that would have proved heretofore an almost impracticable obstacle to the engineer.

Upon the piers and abutments thus built, will be placed the iron superstructure. This being intended for both railway and highway travel, will be 18 ft. wide in the clear. The floor is laid on the bottom of the bridge, so that while being used for the passage of a train, vehicles and horses are of course excluded.

The Hannibal bridge will be substantially of wrought-iron throughout—the top chords of the fixed spans only being of cast-iron. The trusses of the 180-ft. spans are 23 ft. high; of the 250-ft. spans, 25 ft. high, and of the 360-ft. draw span, 26 ft. high at the ends and 34 ft. high at the centre. The respective trusses are divided into panels of about 13 ft. each. The general plan is that known as the Whipple or quadrangular truss, with parallel chords, inclined end braces, vertical posts and diagonal tie rods, the latter passing over two pan-

els each. The iron work is all manufactured at the Detroit Bridge and Iron Works, in this city. The cast-iron is from the best quality of No. 1 Lake Superior charcoal pig. The wrought-iron is guaranteed to be of the best bridge iron, and is all subject to thorough tests in a hydraulic press, all lots from which bars, selected at random, shall break under a tensile strain of 50,000 lbs. per square inch of sectional area, being condemned. After manufacture, and before being placed in the bridge, every bar is placed in the hydraulic press and subjected to an actual tensile strain of 20,000 lbs. per square inch, and while under such actual stress is to be struck several sharp blows with a hammer; and if any show permanent set or any defect whatever under this treatment they are to be condemned. These are very severe tests and only to be endured by the very best iron. The provisions for and the making of such elaborate and complete testing involves great expense and care, but in no other way can perfect materials and work be assured.

The dimensions of the various parts of the bridge are proportioned on the specifications; that a moving load over the bridge of 2,500 lbs. per lineal foot (in addition to the weight of the structure itself, and the flooring and tracks thereon) shall bring on no part a greater strain than one-fifth of its ultimate capacity. Thus, a 250 span with the flooring and tracks thereon, weighs about 260 tons. A moving load of 2,500 lbs. per lineal foot will amount to about 312 tons, which is considerably more than equal to a train of the heaviest locomotives, covering the entire structure. The two together are 572 tons, which is the greatest assumed load that can ever be placed upon the bridge. The factor of safety being 5. gives as the ultimate strength of the bridge 2,860.

The bridge is by contract to be complete and ready for use by August 1, 1871, but it is hoped by the application of extraordinary diligence and energy to anticipate that date.

The amount of materials required for the work embraced in the contract is about as follows:—400,000 lineal feet of piles; 1,000,000 ft. (board measure) of timber and lumber; 10,000 tons of masonry; 10,000 tons of riprap; 4,000 tons of concrete; 1,350 tons of iron.

THE NEW BRIDGE AT ALBANY.—The new iron bridge at Albany, which will open the second great highway over the Hudson, promises to be a very creditable engineering success. Across the main channel of the river are four piers, with 185 ft. span, and with a draw in the centre 272 ft. long and 185 ft. from the pier. Across the basin there are seven spans of 70 ft. each, making the total length of the bridge, including the approaches at either end, 1,550 ft. In height the bridge will be 30 ft. above low-water mark. Across the main channel of the river the bridge will be perfectly level, but after leaving the shore pier on this side there is a slight downward grade. The entire structure is to be of iron of the best quality. It will be provided with double tracks for railroad purposes, and on either side will be a foot bridge 6 ft. wide for the accommodation of pedestrians. The swing bridge in the middle is to be constructed on the most approved principle, and will be operated by steam power, applied so as to move it quickly and with mechanical precision. Two piers of the structure are already completed on the Greenbush side, and work has been begun on all the others. There are now about one hundred mechanics employed on the work, which is to be completed about July or August, 1872. When completed it will be used exclusively for passenger travel, and all freights will be sent across by the old bridge, according to the original plan of the Company. Messrs. Kellogg, Clark & Co., of Philadelphia, are contractors for the iron work. Its total cost will be about $1,000,000, and its projectors claim for it a permanent rank among the finest structures of its kind in the world. Our engineers are making great progress in the art of bridge building, and the United States will soon lead the world in new experiments in this important science.—*Iron Age.*

THE "HODGSON" TRAMWAY AT BRIGHTON.—We understand that the Wire Tramway Company intend removing the experimental length which has been working so successfully on the Downs at Brighton since May last. Those persons who have not already seen it at work should do so before the end of this month, or tney will lose the opportunity. It will be remembered that it was erected to test the capabilities of the system for moving small loads of minerals or farm produce with expedition and at small cost from one place to another over hilly districts. The rope is an endless out-and-home one of ten miles, supported on posts at elevations varying from 37 to 75 ft. above the ground. The loads are placed in boxes, which can be hooked on to the rope at any point by hand, and run off at any point, by small wheels with which the hook blocks are provided, running upon plates or siding rails, so that the boxes can be emptied of their contents. The invention has met with great success abroad, and we have recently heard that the Government of Turkey have decided to erect one or two lengths in that territory.

TELEGRAPHIC COMMUNICATION WITH CHINA.—There is now a good prospect that, before the end of another year, the Chinese coast will be brought within the circuit of telegraphic communication. The wealthy British corporation known as the "Great Northern Telegraph Company," has undertaken the construction of such a line, and the cable of which it is to be composed is already shipped on board the Danish screw frigate, Tordenskjold, which was chartered for the purpose nearly a year ago. The line will consist of 685 nautical miles of main cable, 272 miles of intermediate, 111 miles of ordinary shore end, and 30 miles of heavy shore end—1,098 miles in all, which were manufactured at Charlton, on the Thames, by Messrs. Siemens Bros. The Tordenskjold, which left for China during the month of June last, took the first section of this line, the propeller steamers Great Northern and Cella carrying the remainder. Should these vessels reach their destination in safety, the submarine cable uniting Hong Kong and Shanghai with the East India telegraph system, and thus, indirectly, with Europe and America, will soon be an accomplished fact.

The successful completion of this line will offer better facilities than any which now exist for communication between China and all parts of the world, and the people of this country will share in the advantages of the improvement. But such a line, which can only be made available for the transmission of messages following the most indirect of all possible routes to the East, will not long be adequate to the accommodation of the business which, even at the high rates which will necessa-

rily be charged, it will attract. What is needed is a cable extending from California to the east coast of China, and should such a line be built, there is no doubt that it would at once command a large and profitable business. The completion of this final link in the chain of circumterrestrial telegrapic communication is an undertaking well worthy of the enterprise of the American capitalists to whom the right to lay a cable across the Pacific properly belongs. A proposition to grant such a franchise to an American company, composed of Mr. Cyrus W. Field and others, has been pending in Congress for nearly a year, but, unfortunately, the enterprise resolved itself into a gigantic "job," involving a vast land grant, and a subsidy that would pay the entire expense of laying and operating the line in ten years: and Congress has very properly refused to sanction any such scheme of public plunder. It cannot be long, however, before the importance of such a line will be appreciated by our capitalists, and the work of laying it undertaken without either land grants or Government subsidies. Our trade with China and Japan is still in its infancy, but its promise of future development is encouraging, and a Pacific cable, uniting the British line along the China shore with the American system of land lines, and, through the latter, with several Atlantic cables, could not fail to command a large and profitable business.—*Iron Age.*

NEW BOOKS.

Papers on the Theory and Practice of Coal Mining. By George Fowler, Mining Engineer, Basford, Notts. London: W. M. Hutchings, 5 Bouverie street. For sale by Van Nostrand.

We have in the small volume before us a very clear and able statement of the advantages attendant upon the "long-wall" system of mining, a system which we agree with Mr. Fowler in considering to be one worthy of being adopted far more extensively than it now is. In the opening chapter our author justly observes, that "it is very much the fashion, in the discussion of mining questions, to dilate on the diversity of circumstances, rather than the uniformity of conditions, affecting the working of coal, and he subsequently goes on to show that the different methods of mining adopted in different districts have not really arisen from any inherent peculiarities in those districts; but rather that the diversity in the systems has been caused by the want of ready means of communication, which in early times isolated, as it were, the miners of each of our chief coal fields. In fact, there are to be found in each of these coal fields workings differing from each other in character quite as widely as those of different districts. Again Mr. Fowler points out that if the methods of mining followed had been determined originally by peculiarities in the thickness of the coal and nature of the roof and floor, then it would be reasonable to suppose that in all districts seams worked under like conditions would have been worked in the same way; but this we need hardly say is not the case, and, therefore, there is strong ground for believing that the various systems followed originated, as Mr. Fowler supposes, from there being but little interchange of ideas between the different districts.

This point being allowed, it follows that there is a strong probability not only that one of the systems in use is preferable to all others where it is actually adopted, but also that it is preferable to others generally. This Mr. Fowler considers to be the case with the "long-wall" system, and he advances strong and clearly-stated arguments in support of his conclusion. The first chapter of his book is devoted to a general statement of the forces which operate upon a coal seam, and this portion of the subject is continued in the second chapter, which treats of the loads brought upon pillars in mines of different depths, and explains the manner in which the settlement of the roofs of workings takes place under different conditions.

In his third, fourth, fifth, and sixth chapters, respectively, Mr. Fowler describes the method of working adopted in the North of England, that generally followed in South Wales, the "leading and following up benkwork," principally used in Yorkshire, and the "long-wall" system. The three first-mentioned systems are each illustrated by a plan showing a colliery from which 100 acres of coal are supposed to have been worked, and which is capable of further extension; while the "long-wall" system is illustrated by two plans, each showing a similar colliery, the working in the one case being arranged on a true "long-wall" system, and in the other case on a kind of combination of a "board and pillar" and "long-wall" mine. The various arrangements shown in the plans are described briefly, and their peculiarities and the principles on which they are founded pointed out.

The descriptions of the various systems and their peculiarities occupy about half the book before us, and the remainder of the work is devoted to a comparison of these systems—a comparison which is carried out very fairly, and without any unjust prejudice in favor of the long-wall system. Mr. Fowler states that the elements of the cost of getting coal more or less common to all systems, are: hewing, loading, tramming, and onsetting, strait work, repairs of roads and windings, and interest on capital and plant. Besides these items there is, in the case of long-wall mines, the cost of making goaf roads, the principle of long-wall working being "to work the coal all out in long faces, and to bring the coals through roads packed through the goaf." In the first place our author points out that in all varieties of pillar working the area of pillar left for the support of the first working must increase with an increase of the depth of the mine, and that, therefore, the deeper the mine is, the greater will be the area under operation for a given extraction of coal. As regards the cost of hewing, Mr. Fowler considers that the long-wall method offers undoubted advantages, as where this system is adopted a less amount of side cutting is required to liberate a given quantity of coal than is necessary under other circumstances. The long-wall system also offers the greatest facilities for the employment of coal-cutting machinery, and we are inclined to believe that this latter fact will of itself have ultimately no small effect in promoting the adoption of the long-wall system.

On the cost of loading coal, the system of working adopted has little influence; but with the cost of tramming the case is different. The cost of tramming is made up of "putting" and engine haulage, and referring to the various plans of collieries already mentioned, Mr. Fowler shows that the mean length of "putting" distance will vary from 16 chains in the case of the North of England

system to 7 chains in the long-wall system, the relative cost varying also in the same proportion. The cost of engine haulage, unlike that of "putting," does not exactly vary as the distance through which the tubs are hauled, and Mr. Fowler makes reference to the valuable report of the tail-rope committee of the North of England Mining Institution for detailed information on the subject. The general deduction is, that the haulage costs in well-arranged long wall mines can be brought down to from one-half to two-thirds of those attendant upon other modes of working, while, when the cost of rails required is taken into consideration, there is an equally favorable balance in favor of the long-wall system. Mr. Fowler next compares the reduction of expenses due to the diminution of strait work with the cost of maintaining goaf roads attendant upon the long-wall system, the result being favorable to the latter, while the chapter on cost concludes with some pertinent remarks on the value of the products obtained by the different systems.

The eighth chapter is devoted to a consideration of the question as to how the fire damp given off by the coal can be best dealt with. Mr. Fowler advances good evidence that gas exists in coal in a highly compressed state, and he shows that a cut made across the cleavage planes of a seam drains the gas from the coal far more rapidly than a cut made parallel to those planes. We shall not attempt to epitomize here the various arguments which Mr. Fowler adduces to show that a system like the long-wall, in which the coal is mainly removed in slices parallel to the cleavage planes, is that which affords the greatest chance of security against explosion; but we shall merely remark that they are well founded and worthy of careful attention. As our author shows, the long-wall system affords great facilities for ventilation, and the gas being given off from the coal more gradually than in other methods of working, there is more chance of its being diluted and carried away without doing harm. The effective ventilation of the goaves is also another matter of which Mr. Fowler treats, and he gives much useful information concerning the quantities of doors, stoppings, and brattices, required for ventilating workings and goaves in mines laid out on different systems. Altogether, as we stated in commencing this notice, Mr. Fowler has made out a very strong case for the long-wall system of working, and he has produced an interesting book, which contains much useful information, and which we can strongly recommend to the perusal of all interested in colliery workings.—*Engineering.*

Perpetuum Mobile: or, The History of the Search for Self-Motive Power from the Thirteenth to the Nineteenth Century. Second Series. By H. Dircks, C. E. LL. D., etc E. & F. N. Spon, Charing Cross. For sale by Van Nostrand.

In all ages of mankind there has been a tendency in the minds of practical and non-practical men to produce a machine or apparatus which shall by its own power keep itself moving for an indefinite period after it has been once started. Vast amounts of money have been spent upon the schemes by both rich and poor, for all classes have been led more or less into the belief that perpetual motion can be obtained in some way or other. In reading a work just published by Messrs. Spon, of Charing Cross, we are somewhat moved in wonder as to the large number of individuals who have tried the subject, and who have not only had models made to test their ideas, but have afterwards gone to the expense of patenting them to prevent other persons robbing them of the so-called inventions. The work has been compiled from pamphlets, patent specifications, and other documents, by Mr. H. Dircks, C. E. It is a complete repertory of what has been done on the subject, and should be read by all persons having a mechanical turn of mind, as it exposes the follies of quasi-mechanical men. We have selected the few concluding words of the author, the reading of which will prove the intrinsic value of the book to men of common sense and sound judgment:

"A more self-willed, self-satisfied, or self-deluded class of the community, making at the same time pretensions to superior knowledge, it would be impossible to imagine. They hope against hope, scorning all opposition with ridiculous vehemence, although centuries have not advanced them one step in the way of progress; and while their assumed novelties only prove their discomfiture by a retrograde process.

"Among them is a colonial bishop, a professor of philosophy, and another of languages, two barons, a knight of the most noble and ancient Order of the Temple, four military men, a doctor of medicine, a barrister, several gentlemen, two civil engineers, several mechanical engineers, a brass manufacturer, miller, millwright, smith, saddler, bobbin manufacturer, surveyor, and a geologist, besides others whose professions are not named.

"Among these one might expect to find a sufficient amount of education to have saved them from such an exhibition of misapplied energy as we have here. We can make every allowance for errors arising from the limited means of information possessed by the general public, even until late in the eighteenth century; and can view with curious eye the models and drawings of early artisans. But no apology can be offered for the abortive, ridiculous projects which are a discredit to the present age, enlightened as it is in all mechanical constructions; and the time has arrived when the infancy of mechanical scheming in impossibilities should be laid aside, or left as amusements for youthful amateurs. There is something lamentable, degrading, and almost insane in pursuing the visionary schemes of past ages with dogged determination, in paths of learning which have been investigated by superior minds, and with which such adventurous persons are totally unacquainted. The history of perpetual motion is a history of the foolhardiness of either half-learned or otherwise totally ignorant persons. In the infancy of sciences, whether medicine, chemistry, agriculture, mechanics, or others, there were, of course, some errors which received a certain amount of favor and even encouragement; but the crudities of every science are fast disappearing; alchemy is no more countenanced than is the search for a perpetual motion; and whatever hitherto may have sufficed to give an impulse to the latter has long since subsided, and, therefore, the benighted mechanic must work in unenvied seclusion; for there is no longer any expectation of applying such mechanism to the determining of the longitude, or of obtaining for its discoverer any Government reward.

"Were we to admit for argument's sake that some delicately arranged instrument might possi-

bly be contrived to show a tremulous action, its accomplishment would not be of the least practical value, or reward the toil and anxiety of its inventor. But, although inventors have sought a power exceeding the steam engine in some cases, while others have satisfied themselves with more lowly designs based on capillary attraction, neither the one nor the other has attained the faintest shadow of success. From the infant machines projected in the thirteenth century to the last hydraulic, pneumatic, weighted, and lever-worked pretensions patented as motions, no motion whatever has resulted from the one or the other to the present day. Not a solitary discovery is on record, not one absolutely ingenious scheme projected, or one simple self-motive model accomplished. Under such circumstances what shall we say of the modern mechanic who shall hereafter presume to add his dreary dreams to the lifeless lumber of the last seven centuries? No language can be too severe in denouncing the continuance of research in this insane undertaking; nor any criticism too sarcastic in exposing the foolish results pompously published by a class of blind, deaf, and doggedly stupid projectors, who, bringing obloquy on themselves, are a discredit both to their country and to the present enlightened age. Nothing can excuse the fostering of such crazed conceits as the present history records, curious in themselves as regards olden times, but ridiculous in a modern garb; they are, therefore, presented here as a warning to simple-minded experimenters and novices in mechanical science, in the hope thereby effectually to break the neck of this monster mechanical delusion."—*Mechanics' Magazine.*

The Kansas City Bridge, with an account of the regimen of the Missouri River, and a description of methods used for founding in that river. By O. Chanute, Chief Engineer, and Geo. Morison, Assistant Engineer. New York: D. Van Nostrand, 1870.

This fine quarto is a rare addition to the literature of practical engineering. Such books from American engineers are scarce. The skilled members of the profession too often feel that they have discharged their whole duty, in successfully constructing the works under their charge; the lessons drawn from their experience are barely mentioned to a few professional friends, or, in rare cases, become the subject of a paper to be stored away in the archives of some society. The work of collating and arranging the records of such experiences is presumed to belong to another profession, if, indeed, there is a presumption that it is anybody's business. But the sum of such practical experiences constitutes engineering science. It is only he who builds, that knows how far the intricate formulas of physical science give results that accord with the exigences of the field, and it is such knowledge that is of especial value to the rising members of the profession.

The authors of the present work have realized the important relation they sustained to the confraternity of engineers, and have detailed with a rare felicity of method the practical devices by which they as engineers overcame great difficulties

The story is completely told; from the discussion of the physical character of the section which belonged to the reconnoissance, to the estimates and tests of deflection under change of temperature, or addition of a load—nothing relating to practical experience, whether mishap or success, is witheld.

The articles "Kansas City Bridge," and "Pier No. 4," in recent numbers of this Magazine, have, we are sure, sufficiently attested the value of this work to scientific readers. The book is beautifully printed, and is enriched with five lithographic views and twelve plates.

A Treatise on the Principles and Practice of Levelling, Showing its Application to Purposes of Railway Engineering and the Construction of Roads. By Fred. W. Simms, C. E. From the fifth London edition, revised and corrected; with the addition of "Law's Examples of Railway Curves." New York: D. Van Nostrand.

This book was originally designed for young engineers who were obliged to work out the theory of levelling without the aid of an instructor. It is probably more widely known than any other book of its class. The explanations of the theory of levelling are of the clearest possible kind, and the applications are such as to enable the student to acquire the requisite skill in adjusting and working the instrument without other aid.

Law's curves furnish an epitome of the practical processes of laying out curves according to the best methods now in use.

The American edition presents the advantage over the London edition of exhibiting the diagrams on the same page as the reference in the text.

Researches on Diamagnetism and Magne-Crystallic Action, including the Question of Diamagnetic Polarity. By John Tyndall, LL.D., F.R.S., etc., Professor of Natural Philosophy in the Royal Institution of Great Britain. London: Longmans, Green & Co., 1870. For sale by Van Nostrand.

The work before us is a first instalment of the collected publication of the author's original memoirs on experimental physics, communicated by him to the "Philosophical Transactions" and the "Philosophical Magazine," during the last eighteen years. These researches were begun at Marburg at the close of 1849, and have been since continued at Berlin, and completed in England. In the introdution to this series of memoirs, the author relates the discovery of, and first researches on, diamagnetism, by the celebrated Faraday. The first 184 pages are devoted to eight memoirs by the author, and the remainder of the volume contains letters, essays, and reviews relating to magnetism and electricity; the work as it is gives to the reader a very complete and excellent account of all facts and theories relating to this portion of natural philosophy. It is copiously illustrated with plates and wood-cuts, and is, in every sense of the word, a most interesting as well as useful publication.

Explosions of Steam Boilers. How they are caused and how they may be prevented. By J. R. Robinson. Boston: Little, Brown & Co. For sale by Van Nostrand.

The author of this little volume is a practical engineer and has evidently been a close observer of the phenomena attendant upon steam-boiler explosions. He advances the theory that, under some conditions of interior boiler surface and of feed water, there is no contact of water with the heated surface, even at considerable depths below the water level; that there is a decided repellant

action between the water and the metal, even at temperatures and pressures which are quite common in working boilers. A variation in temperature in the boiler surface, or of pressure on the water, may enforce a contact of liquid metal at a critical moment, and cause such a violent vaporization of the water as to cause an explosion.

Mr. Robinson's conclusions seem to be fairly enough drawn from his experiments, and it is evidently a profitable field for further trials.

It is to be hoped that the limiting temperatures at which such action as above described can occur, may be determined for all conditions of the water as to substances in solution, and for the different states of boiler surface.

The book is printed in a much neater style than is common with works on kindred subjects.

Earth and Sea. From the French of Louis Figuier. Translated, edited, and enlarged by W. H. Davenport Adams. Illustrated with 250 engravings by distinguished artists. For sale by Van Nostrand.

This is simply a work on Physical Geography, beautifully printed and illustrated, and expanded by descriptions of remarkable localities, to the unprecedented dimensions of 700 pages, royal octavo.

It is well known that Figuier aims in his works at making science look attractive by keeping its technicalities out of view and bringing forward and illustrating the striking phenomena and features. Such books find their uses in attracting to the severer study of science young readers who would not otherwise be drawn from easier studies or diversions.

This new work is more to our liking than either of the preceding ones by this author. The peculiarities above referred to are manifested in the large space afforded to avalanches, earthquakes, volcanoes, and like phenomena, and the absence of classifications of winds, currents, climates, etc.

It is a beautiful book for the private library, and will prove deeply interesting to the general scientific reader.

The Elements of Mechanism. By T. M. Goodeve, M.A. London: Longmans. For sale by Van Nostrand.

This book, designed especially for students of applied mechanics, has been published previously as a separate and independent work, but has now been rewritten and enlarged, in order to fit it to form one of the series of Elementary Text-books on Mechanical and Physical Science in course of publication by Messrs. Longmans. It contains descriptions with illustrations of all the more important mechanical movements, with chapters on "the Teeth of Wheels;" on "the Use of Wheels in Trains," including articles on the "Screw-cutting Lathe, Cranes, and the Connection of Axes;" on "Agregate Motion," and articles on numerous miscellaneous contrivances. The volume will prove a handy *vade-mecum* to all students of mechanics as applied to the industries of the world. It is well printed, and the cuts are, as a rule, illustrations of the actual movements to be observed in existing machines.

A Practical Treatise on Soluble or Water Glass, Silicates of Soda and Potash for Silicifying Stones, Mortar, Concrete, and Hydraulic Lime, rendering Wood and Timber Fire and Dry-Rot Proof. By Dr. Lewis Feuchtwanger. New York: L. & J. W. Feuchtwanger. For sale by Van Nostrand.

The various uses of soluble glass were fully set forth in the last number of our magazine. The book before us presents a compilation of all the author could find in journals and Patent Office reports.

A large space is devoted to limes and cements, and proposed applications of soluble glass in connection with them.

The work bears marks of haste in its preparation, but from the large fund of information on mineralogical and chemical subjects, promised by the author, the book cannot fail to be of value.

Light-houses and Light-ships. A Descriptive and Historical Account of their Mode of Construction and Organization. By W. H. Davenport Adams. London: T. Nelson & Sons. For sale by Van Nostrand.

The topics discussed in this little book are under the following heads:

1. Ancient history of light-houses.
2. The science of light-houses,
3. Light-houses of Great Britain.
4. Light-houses of France.
5. The auxiliaries of light-houses.
6. Life in the light-house.

The illustrations are excellent and numerous, and the work is a good addition to the list of popular scientific treatises which have appeared within the last two years.

The Naval Dry Docks of the United States. By Chas. B. Stuart. Illustrated with twenty-four fine engravings on steel. Fourth edition. 4to, 220 pages. New York: D. Van Nostrand.

The value of this work is attested by engineering readers whose libraries are enriched by the three previous editions.

The Manual of the Hydrometer, with Chapters on Oxidation and Depositions in Marine Boilers. By Lionel Swift, R.N. Portsmouth, Eng.: Griffen & Co. For sale by Van Nostrand.

Contents: Hydrometers and their use, with practical examples; Specific gravity of sea water; Amount and character of saline ingredients; On the deposits in marine boilers; Causes and prevention of boiler priming; Oxidation in boilers—cause and prevention; Practical summary of the management of boilers and superheaters.

MISCELLANEOUS.

Faure's Battery.—Faure's element is a modification of that known as Bunsen's, the poles consisting of carbon in strong nitric acid and amalgamated zinc in dilute sulphuric acid. In Bunsen's ordinary form of carbon element the carbon pole is immersed in a vessel holding a considerable quantity of nitric acid, which, as it becomes de-oxidized by the electrolytic action of the current, liberates nitrous acid gas, which rises into the air, rendering it unwholesome to breathe, and destructive to most metallic apparatus in its neighborhood. The purpose of Faure's battery is to obviate these drawbacks. This is effected by confining the nitric acid inside the carbon pole and allowing only sufficient acid to percolate through

it, in order to keep up the necessary electrolytic action of the element. The carbon pole is made in the form of an ordinary bottle, and is provided with a carbon or platinum stopper, to which the binding screw of the pole is attached. This bottle, which fulfils at once the functions of both pole and porous diaphragm, is placed concentrically in the interior of a cylinder of amalgamated zinc. And the whole is contained in an earthenware jar. When set up for action the bottle is nearly filled with the nitric acid, and the space containing the zinc, between the bottle and the outer jar, to the required height with the dilute sulphuric acid. The slight liberation of gas within the bottle causes a sufficient pressure to be exerted upon the nitric acid to force it gradually through the carbon. In this way the exterior of the carbon pole remains immersed in a very thin layer of nitric acid immediately opposite to the zinc, which is in course of dissolution in the dilute sulphuric acid In point of constancy this element is superior to either Bunsen's or Grove's, because the body of nitric acid remaining protected within the bottle does not become weakened, as is the case with those forms of elements in which the two fluids are exposed in larger quantities and separated by porous diaphragms. It acts also entirely without any disengagement of gas into the air, so that it may be used in any room without disagreeable consequences. A variety of forms might no doubt be given to these elements which would enable them to fulfil the desired object. Those which I have placed upon the table were designed and manufactured by Messrs. Elliott Brothers, and are found to be convenient for experimental purposes as well as for use in telegraph offices.—*The Artizan.*

STEEL SPRING MOTOR FOR STREET CARS.—The following is a description of a new application of steel spring which has been patented recently by P. E. McDonnell, of Chicago :—"In the device, coil springs about twenty inches wide, three-sixteenths of an inch thick, and of suitable length, are placed under the platforms, and by means of suitable gearing their power is concentrated on a shaft, from which it is taken and applied to rotating the journals, the springs uncoiling slowly, but giving a quick rotary motion to the car wheels. One or both springs may be used, as the case may require, and the gearing may be reserved to move the car in either direction, while a governor regulates the speed. The car is under the perfect control of the engineer, and it can be stopped and started much quicker than when operated by horses ; inasmuch as the power required to propel the car is used to stop it, and the inertia acquired in running is used to stop it, very ingenious machinery being used to accomplish this result. It is expected that an engine will be used at the end of the route to wind up the springs, an operation requiring about two minutes and a half time, and when wound, they are supposed to propel a car five miles, carrying sixty passengers. One great peculiarity in the mechanism consists in the fact that the movement of the car down an incline is made to wind up a spring, which is used to propel the car up grade."

NEW GOLD WASHING APPARATUS.—An ingenious and very complete apparatus for working auriferous river beds has been invented by Mr. A. F. Errington, of Sebastapol, Ballarat. The first cost of the apparatus complete is between £6,000 and £7,000, the total working expenses are calculated at £160 per week, and wash-dirt yielding only 5 dwts. per ton upon the average will realize no less than $2,000 sterling per week. The boat is to be propelled by a Penn's oscillating cylinder-engine, with undershot water-wheels to increase (?) the motive-power, the engine also working the gold-washing machinery. A vertical rod passing through an aperture in the hold serves for the buckets to descend upon to the river bed. The wash-dirt raised by the bucket to the upper deck is discharged into a hopper, wherein water pumped up through a hollow mast is thrown upon it. After being washed through perforated cylinders the valuable portion of the dirt is received in two cradles, from which the auriferous deposit is lifted by hand into revolving basins in which the heavier gold is separated from the debris.

UTILIZING COAL WASTE.—Perhaps one of the most important, inasmuch as it has been demonstrated to be practical, inventions of the day, in view of the high prices of fuel, is that referred to under the above caption. Some time since, a company was formed in this city, with a view to utilizing the refuse of coal mines, the accretions of which have not only been enormous, but of serious inconvenience to the operator, and hitherto valueless. The enterprise has proved a complete success, buildings and machinery have been erected at Mauch Chunk, and the fuel, as prepared from the coal dust, is said to be superior to the natural coal, burning without cinder or impurity of any kind. Unfortunately for the good of the general public, the Secretary of the Navy, after testing the fuel, has entered into a contract for all the present works are capable of turning out. The fuel, as supplied the government, is in cubes of five inches. From the regularity of shape, great advantage can be had in stowage, while the absence of cinder and, comparatively, of ashes, renders it peculiarly desirable. The price is said to be lower considerably than that of coal in its present form. The supply of the refuse is inexhaustible, and this improvement gives us another advantage over the impracticable miners, who may strike at will if we can but utilize the dust which we have above ground by millions of tons. As a process has been lately ventilated by which coal has been ground to a fine dust, and carried by blowers into the furnace with sufficient air to produce immediate combustion, and with the most eminent success, we suggest the use of the dust already on hand for similar treatment, not doubting equal results will be obtained. Any process or invention which cheapens the necessaries of life to the consumer is of prime value, and as fuel may be looked upon as the *sine qua non* of industry, as of comfort, the inventions alluded to deserve more than casual notice.—*Iron Age.*

WHEN 2 or 4 per cent. of finely pulverized althea root (marsh mallow) is mixed with plaster of Paris, it retards the hardening, which begins only after half an hour's time. When dry, it may be filed cut, or turned, and thus become of use in making domino-stones, dies, brooches, snuff-boxes, etc. Eight per cent. retards the hardening for a long time, but increasing the

tenacity of the mass. The latter may be rolled out on window-glass into thin sheets, which never crack in drying; may be easily detached from the glass, and take on a polish readily by rubbing them. This material, if incorporated with mineral or other paints, and properly kneaded, gives very fine imitations of marble, and can be colored when dry, and can be made waterproof by polishing and varnishing. The chemist and chemical manufacturers will find it an excellent luting for vessels of every kind.

Probably the best polishing powder for metals of medium hardness and for glass would be that used by Lord Rosse for polishing the speculum of his large telescope. He thus describes his method of preparing it: "I prepare the peroxide of iron by precipitation with water of ammonia, from a pure dilute solution of sulphate of iron. The precipitate is washed, pressed in a screw-press till nearly dry, and exposed to a heat, which, in the dark, appears a dull, low red. The only points of importance are that the sulphate of iron should be pure and the water of ammonia should be decidedly in excess, and that the heat should not exceed what I have described. The color will be a bright crimson, inclining to yellow. I have tried both potash and soda, pure, instead of water of ammonia, but after washing with some degree of care, the trace of the alkali still remained, and peroxide was of an ochrey color, and did not polish properly."

According to Dr. R. Fresenius, the weighed quantity of iron to be tested for carbon is placed on a small porcelain boat, and introduced into a hard glass combustion tube, placed in a combustion furnace, and, when red hot, a current of dry chlorine gas (dried by making it pass over pieces of pumice-stone moistened with strong sulphuric acid), is passed over; the current of gas and application of a low red heat is continued until all the iron is volatilized as chloride. The carbon left in the small boat is, after the apparatus has cooled, placed in a porcelain tube and burned. After being heated to redness in a current of oxygen, the products of the composition are taken up by Liebig's potash bulbs. Great care is required that the chlorine be thoroughly dry, since, otherwise, hydrocarbon may be formed and some carbon lost.

Prof. J. B. Schnetzler, in his observations on the spontaneous motion of the protoplasm in the cells of the leaves of the common water-weed, *Anacharis alsinastrum*, recently published expresses the opinion that the principal cause which provokes the motion is the chemical action of oxygen, which passes through the wall of the cell, and of which a portion is probably transformed into ozone under the influence of light, as occurs also in the globules. The currents thus produced are influenced by the highest refracted rays of light, and also, probably, by electricity formed under the influence of water between the surface of the leaf and the contents of the cells.

In Belgium furnace slag is now utilized by allowing it to run off into moulds along the sides of the furnace, in which it assumes the form of rectangular blocks of any size. When cold, the mass forms a compact, homogeneous slag, very much resembling porphyry, and equal, for building and engineering purposes, to the best natural stone that can be procured from the quarry.

Commerce of the World.—France exports wines, brandies, silks, fancy articles, furniture, jewelry, clocks, watches, paper, perfumery, and fancy goods generally.

Italy exports corn, oil, flax, wines, essences, dye stuffs, drugs, fine marble, soaps, paintings, engravings, mosaics and salt.

Prussia exports linens, woollens zinc, articles of iron, copper and brass, indigo, wax, hams, musical instruments, tobacco, wine and porcelain.

Germany exports wool, woollen goods, linens, rags, corn, timber, iron, lead, tin, flax, hemp, wine, wax, tallow, and cattle.

Austria exports minerals, raw and manufactured silk, thread, glass, wax, tar, nutgall, wine, honey, and mathematical instruments.

England exports cotton, woollens, glass, hardware, earthenware, cutlery, iron, steel, metallic wares, salt, coal, watches, tin, silks and linens.

Russia exports tallow, flax, hemp, flour, iron, copper, linseed, lard, hides, wax, ducks, cordage, bristle, furs, potash and tar.

Spain exports wine, brandy, oil, fresh and dried fruits, quicksilver, sulphur, cork, saffron, anchovies, silks and woollens.

China exports tea, rhubarb, musk, ginger, borax, zinc, silks, cassia, filigree works, ivory ware, lacquered ware and morocco.

Hindostan exports gold and silver, cochineal, indigo, sarsaparilla, vanilla, jalap, fustic, campeachy wood, pimento, drugs and dye stuffs.

Brazil exports coffee, indigo, sugar, rice, hides, dried meats, tallow, gold, diamonds and other precious stones, gums, mahogany and india rubber.

West Indies export sugar, sugar molasses, rum, tobacco, cigars, mahogany, dye woods, coffee, pimento, fresh fruit and preserves, wax, ginger and other spices.

Switzerland exports cattle, cheese, butter, tallow, dried fruits, linen, silks, velvets, lace, jewelry, paper, and gunpowder.

East India exports cloves, nutmegs, mace, pepper, rice, indigo, gold dust, camphor, benzine, sulphur, ivory, rattans, sandal wood, zinc, and nuts.

United States exports, principally, agricultural produce, cotton, tobacco, flour, provisions of all kinds, lumber, turpentine, wearing apparel.—*Iron Age.*

Drawing an analogy from the motion of a cannon ball, we shall find that, supposing the earth to be arrested suddenly while travelling through space at the rate of 19 miles per second, as much heat would be developed as would be given off from the combustion of a volume of oil 14 times the size of the earth.

In front of Krupp's establishment shells of the largest calibre are to be seen lying. They are in the form of a pointed cylinder, and are 3 ft. long and 14 in. in diameter. When filled with their charges (76 lbs. of powder) they weigh 739 lbs. A hundred of these explosive projectiles have been ordered to be forwarded to Paris as speedily as possible.—*The Engineer.*